

Engineering Design File

PROJECT NO. 23927

Chemical Compatibility and Inventory Evaluation for the Accelerated Retrieval Project for a Described Area within Pit 4



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CONTENTS

ACRONYMS.....	5
1. INTRODUCTION	7
2. BACKGROUND	7
2.1 Subsurface Disposal Area and Operations	7
2.2 Pit 4.....	10
2.3 Designated Area Definition.....	10
2.4 Waste Generators.....	13
2.4.1 Idaho National Engineering and Environmental Laboratory	13
2.4.2 Rocky Flats Plant	14
2.5 Data Sources.....	14
3. CHEMICAL COMPATIBILITIES	54
3.1 Purpose	54
3.2 Summary of Existing Technical Documentation and Evaluation Process	54
3.2.1 Chemical Compatibility Evaluation.....	56
4. CONCLUSIONS	58
5. REFERENCES.....	58
Appendix A—Potassium and Sodium Nitrate	61
Appendix B—Waste Types by Disposal ID Number for the Waste Inventory Contained in the Described Area Including the Angle of Repose	69

FIGURES

1. Map of the Idaho National Engineering and Environmental Laboratory showing locations of the Radioactive Waste Management Complex and other major facilities.....	8
2. Accelerated Retrieval Project area within the Subsurface Disposal Area.....	9

TABLES

1.	RFP waste content in the designated retrieval area of Pit 4 within the SDA	11
2.	Onsite generators that disposed waste in designated area of Pit 4	13
3.	Rocky Flats Plant generators that disposed waste in designated area of Pit 4	14
4.	List of chemicals that may be present in Area 1 of Pit 4 as determined in the development of the acceptable knowledge	15

ACRONYMS

ANL	Argonne National Laboratory
ANL-W	Argonne National Laboratory-West
AK	Acceptable Knowledge
ARA	Auxiliary Reactor Area
ARP	Accelerated Retrieval Project
CFA	Central Facilities Area
CPP	Chemical Processing Plant
DOW	Dow Chemical
DRI	Denver Research Institute
EDF	Engineering Design File
EPA	Environmental Protection Agency
HDT	Historical Data Task
ID	Idaho
INEEL	Idaho National Engineering and Environmental Laboratory
INEL	Idaho National Engineering Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LLW	low-level waste
MCP	management control procedure
NRF	Naval Reactors Facility
NTCRA	non-time critical removal action
PER	Power Excursion Reactor
RF	Rocky Flats
RFO	Rocky Flats Operation
RFP	Rocky Flats Plant
RWMC	Radioactive Waste Management Complex
SDA	Subsurface Disposal Area
TAN	Test Area North
TRA	Test Reactor Area
TRU	Transuranic
USGS	United States Geological Survey
USQ	Unresolved Safety Question
VOC	volatile organic compound
WILD	Waste Inventory Location Database

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Chemical Compatibility and Inventory Evaluation for the Accelerated Retrieval Project for a Described Area within Pit 4

1. INTRODUCTION

The Radioactive Waste Management Complex (RWMC) at the Idaho National Engineering Laboratory (INEEL) (Figure 1) was used for subsurface disposal of transuranic (TRU) waste in various pits and trenches of the Subsurface Disposal Area (SDA) from 1952 until 1970, when the practice was suspended in favor of aboveground, retrievable storage. Low-level waste (LLW) from the INEEL and elsewhere was also disposed of in these pits and trenches. As part of a Comprehensive Environmental Response, Compensation, and Liability Act (42 USC § 9601 et seq., 1980) non-time critical removal action (NTCRA), the U.S. Department of Energy proposes to retrieve some of this waste in the SDA. The Accelerated Retrieval Project (ARP) intends to retrieve and process waste from a designated area in Pit 4 of the SDA within the Radioactive Waste Management Complex as the area to be remediated under this NTCRA. The focused objective of the NTCRA is targeted retrieval of certain Rocky Flats Plant waste streams that are highly contaminated with TRU radionuclides, VOCs, and isotopes of uranium. To achieve this objective, the NTCRA targets removal of only the following Rocky Flats Plant waste streams: Series 741 and 743 sludge; graphite; filters; and roaster oxide waste.

As part of the retrieval process it is necessary to consider the range of possible chemical combinations that could occur during excavation, repackaging, and storage. The potential adverse chemical reactions (e.g., generation of fire, explosion, heat, or fumes) that stem from combining chemicals at ambient temperatures need to be considered to support safe and compliant onsite waste management and to support waste certification and shipping of the retrieved waste to the Waste Isolation Pilot Plant. The purpose of this document is to document the chemical inventory within wastes buried in the designated retrieval area and to document evaluation of the chemical compatibility of the buried wastes. The study in this Engineering Design File (EDF) investigates the possibility of adverse chemical reactions that could occur during Accelerated Retrieval Project excavation, repackaging, or storage.

2. BACKGROUND

The following sections provide historical background of the SDA and waste disposed of in Pit 4. The *Engineering Evaluation/Cost Analysis for the Accelerated Retrieval of a Designated Portion of Pit 4* (DOE-ID 2004a) contains further background of the operational history of the RWMC and the INEEL.

2.1 Subsurface Disposal Area and Operations

Currently, the RWMC covers 71.6 ha (177 acres) in the southwestern quadrant of the INEEL. This includes the administration area of approximately 8.9 ha (22 acres), the SDA, and the TSA (established in 1970 at 23.3 ha [58 acres]). Figure 2 provides a map of the RWMC showing the location of pits, trenches, and soil vaults in the SDA. Pit 4, which includes the designated retrieval area, is located in the approximate center of the SDA. In 1952, the SDA was established at 5.26 ha (13 acres) for disposal of solid radioactive waste. Burial of defense waste with TRU elements from the Rocky Flats Plant (RFP) began in 1954. By 1957, the original SDA was nearly full. In 1958, the SDA was expanded to 35.6 ha (88 acres), which remained the same until 1988 when the security fence was relocated outside the dike surrounding the SDA and the current size of 39.3 ha (97 acres) was established. Approximately 62 of the total 97 acres are open areas that do not contain waste (e.g., area between pits and trenches and dikes surrounding the entire landfill).

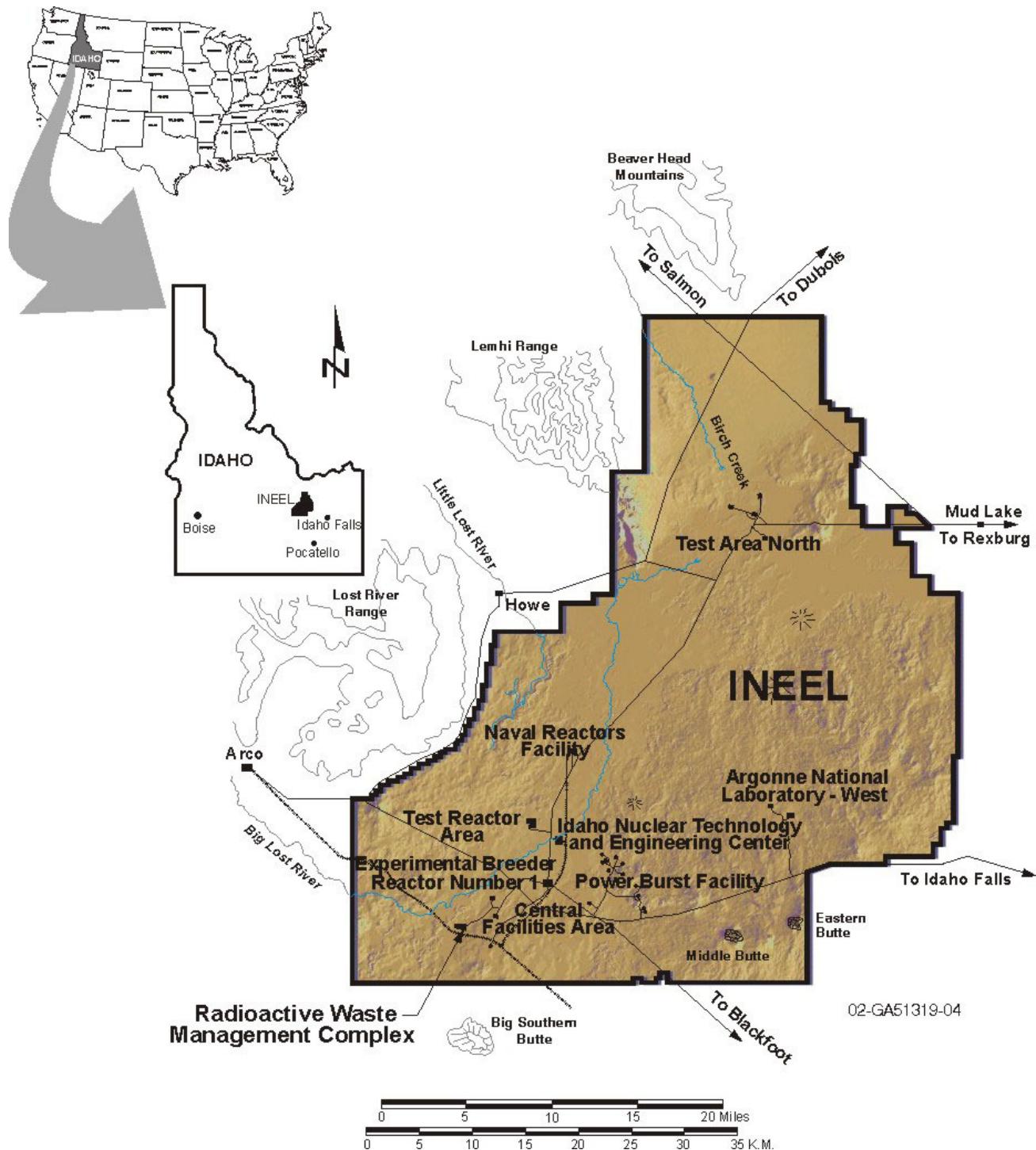


Figure 1. Map of the Idaho National Engineering and Environmental Laboratory showing locations of the Radioactive Waste Management Complex and other major facilities.

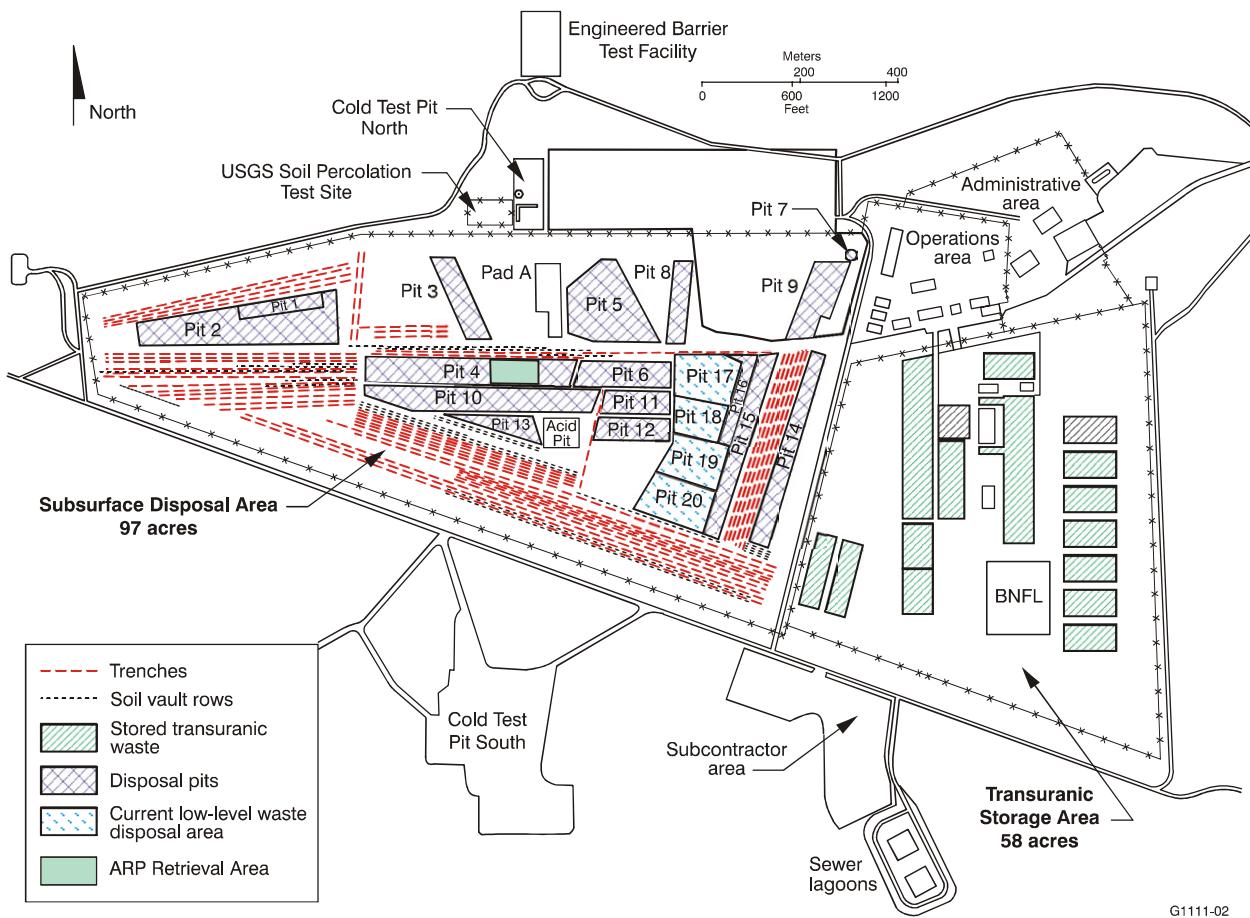


Figure 2. Accelerated Retrieval Project area within the Subsurface Disposal Area.

From 1952 to 1970, radioactive waste was buried in pits, trenches, and soil vault rows excavated into a veneer of surficial sediment. This sediment is underlain by a thick series of basaltic lava intercalated with sedimentary deposits. In 1970, the shallow burial of TRU waste ended, burial of other radioactive waste has continued. Since 1970, TRU waste has been stored on aboveground asphalt pads in retrievable containers. Since 1985, waste disposal in the SDA has been limited to low-level radioactive waste from INEEL operations. Between 1952 and 1997, approximately $215,000 \text{ m}^3$ (281,209.4 yd^3) of radioactive waste containing about 12.6 million Ci of radioactivity was buried at the SDA (French and Taylor 1998). A 1998 inventory of amounts of 38 radioactive buried contaminants (Becker et al. 1998) was updated in 2002 for 25 radionuclides in the *Ancillary Basis for Risk Analysis of the Subsurface Disposal Area* (Holdren et al. 2002).

Between 1960 and 1963, the RWMC accepted radioactive waste from private sources such as universities, hospitals, and research institutes. This service stopped in September 1963 when commercial burial sites became available for contaminated waste from private industry. When the TSA became operational, asphalt pads were constructed on which TRU waste was stacked and then covered with plywood, plastic sheeting, and 1 m (3 ft) of soil. From 1975 to 1996, air-support buildings were used to protect recently received waste containers during stacking operations. These support structures were emptied in 1996 and decommissioned in 1998.

In the fall of 1988, the INEEL stopped receiving shipments of TRU waste to the RWMC from out-of-state sources.

2.2 Pit 4

Pit 4 was open to receive waste from January 1963 through September 1967. Pit 4, shown on Figure 2, is located in the approximate center of the SDA and shares a common eastern boundary with Pit 6. Pit 4 has a surface area of 9,948.2 m² (107,082 ft²). The total volume of Pit 4 is estimated at 45,307 m³ (1,600,000 ft³) (Holdren et al. 2002). Based on disposal practices at the time, containerized waste, primarily from the RFP in Colorado, was initially stacked in the pit. In November 1963, this practice was changed, and containers were dumped into pits rather than stacked to reduce labor costs and personnel exposures. Based on this operational change and the timeframe of disposal, it is expected that the RFP waste within the designated retrieval area was dumped rather than stacked. Additional waste from INEEL waste generators and some waste from off-site generators also was disposed of in the pit.

The disposal process in the 1960s involved excavating an area in the SDA with tractor-drawn scrapers down to underlying basalt outcroppings then backfilling and leveling the newly constructed pit floor with a layer of native soil approximately 0.6 m (2 ft) thick. Waste in drums; cardboard, wood, and metal boxes; and other containers was disposed of. Soil was sometimes added as an interim step as waste was being emplaced and while the pits remained open. After a large area was full, pits were backfilled and initially covered with about 1 m (3 ft) of soil, commonly referred to as overburden soil. Additional overburden was added over time to repair subsidence and promote surface drainage. The estimated overburden thickness currently over Pit 4 ranges from 1.2 to 2.1 m (4 to 7 ft). After approximately 40 years of burial, original disposal containers, including the carbon steel drums, are expected to be significantly corroded and degraded similar to drums removed from Pit 9 in early 2004 by the Glovebox Excavator Method Project.

The summary characteristics column in Table 1 shows that the RFP waste forms contain various radiological and nonradiological contaminants. The material shipped to Pit 4 from RFP included weapons-grade plutonium, Am-241, and uranium isotopes. Weapons-grade plutonium (i.e., Pu-52) contains Pu-238, Pu-239, Pu-240, Pu-241, and Pu-242. In addition, some Am-241 and Np-237 are daughters resulting from the radioactive decay of Pu-241. Also included in the waste shipments was additional Am-241. This Am-241 did not result from the decay of Pit 4 inventory but was removed from Pu-52 during processing at RFP. This additional Am-241 is a significant contributor to the total radioactivity located in Pit 4. Uranium isotopes shipped to the RWMC included U-235 and U-238. A number of radionuclides including Co-60, Cs-137, Sr-90, Y-90, and Ba-137, which originated primarily from INEEL waste generators, may also be found in Pit 4.

The primary chemicals known to be in Pit 4 are presented in Table 4 below (see Section 2.5) based on information associated with the AK summary report prepared for the Accelerated Retrieval Project.

2.3 Designated Area Definition

A study was conducted, as part of the Pit 9 Stage III Project, to evaluate and prioritize various areas of the SDA for possible removal of TRU contamination and hazardous volatile organic compounds (VOCs). These were evaluated against a number of criteria (e.g., total TRU content, total VOC content, and accessibility). The designated portion of Pit 4 was selected because it contains high concentrations of TRU waste and also contains significant volumes of other targeted waste forms, including VOCs and uranium. The approximate 1/2-acre size was selected based on the estimated distribution of waste in the pit and other engineering factors (e.g., economies of scale associated with retrieval). The retrieval area of focus comprises approximately 21% of the overall area of Pit 4 with approximate dimensions of 38.4 × 80.2 m (126 × 263 ft).

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Table 1. RFP waste content in the designated retrieval area of Pit 4 within the SDA.

Item	Description	Code (IDC)	Summary Characteristics	Packaging	Volume (ft ³)	Estimated Waste TW/NTW
Series 741 first-stage sludge	001	Salt precipitate containing plutonium and americium oxides, depleted uranium, metal oxides, and organic constituents.	18.1 to 22.7 kg (40 to 50 lb) of Portland cement added to top and bottom of drum to absorb any free liquids. Encased in two plastic bags.		6,614	TW
Series 742 second-stage sludge	002	Salt precipitate containing plutonium and americium oxides, metal oxides, and organic constituents.	18.1 to 22.7 kg (40 to 50 lb) of Portland cement added in layers to absorb any free liquids. Encased in two plastic bags.		5,814	NTW
Series 743 sludge organic setups	003	Organic liquid waste solidified using calcium silicate (pastelike or greaselike).	113.6 L (30 gal) of organic waste mixed with 45.4 kg (100 lb) calcium silicate. Small quantities (4.5 to 9.1 kg [10 to 20 lb]) of Oil-Dri added to top and bottom, if necessary. Encased in two plastic bags.		5,123	TW
Series 744 sludge special setups	004	Complexing chemicals (liquids) including Versenes, organic acids, and alcohols solidified with cement.	86.2 kg (190 lb) of Portland cement and 22.7 kg (50 lb) of magnesia cement in drum followed by the addition of 99.9 L (26.4 gal) of liquid waste. Additional cement added to the top and bottom. Encased in two plastic bags.		690	NTW
Combustible, noncombustible, and mixed debris	Various	Solid radioactively contaminated combustible debris items such as paper, rags, cardboard, and wood. Noncombustible debris varies widely including pipe, empty drums, glass, and sand. Some waste is contaminated with beryllium metal.	Varies by process line generating the waste. Waste may have been wrapped in plastic or placed directly into the waste container.		68,898	NTW

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Table 1. (continued).

Waste Stream	Item Description Code (IDC)	Summary Characteristics	Packaging	Estimated Waste Volume (ft ³)	TW/NTW
Roaster oxide waste	Unassigned	Incinerated depleted uranium. Primary chemical form is uranium oxide with some metal possible.	Packaged in metal drums with inner plastic bag packaging.	801	TW
Graphite	300, 301, 310, 311	Graphite mold pieces after excess plutonium removal. Molds are broken into large pieces before packaging. Graphite fines (e.g., scarfings) packaged in small bottles.	Drums lined with polyethylene bags and, most likely, a cardboard liner. Bottles of graphite fines were individually wrapped in plastic bags.	1,501	TW
Filters	490	Discarded high-efficiency particulate air filters contaminated with RFP radionuclides such as plutonium and americium.	Packaged in cardboard cartons and boxes depending on the timeframe of disposal.	12,593	TW

TW = Targeted Waste

NTW = Non-targeted Waste

2.4 Waste Generators

Waste disposed in the designated area of Pit 4 originated from onsite sources at the INEEL and offsite from the RFP. The following is a listing on onsite generators associated with waste disposed in the designated area of Pit 4. These were determined using the generator property associated with each shipment in the Waste Inventory Location Database (WILD).

2.4.1 Idaho National Engineering and Environmental Laboratory

The following is a list of onsite generators that disposed of waste in the designated area in Pit 4.

Table 2. Onsite generators that disposed waste in designated area of Pit 4.

Building	Name / Function
ANL 601	Building 601
ANL 767	EBR-II Reactor (EBR-II)
ARA 602	AREA-SL-1 Reactor
CFA 601	Warehouse
CFA 633	Health Physics Instrument Lab
CFA 654	Old Craft Shop
CFA 687	Old Lead Shop
CFA 690	Radiological/Environmental Lab
CPP 601	Fuel Separation Area
CPP 630	Safety/Spectrometry
NRF 601	S1W
NRF 618	ECF - Expended Core Facility
PER 601	Building 601
TAN 607	Hot Shop/Manufacturing and Assembly
TAN 633	Hot Cell Annex
TRA 603	Deep Well Pumphouse 2
TRA 642	Engineering Test Reactor (ETR)

ANL = Argonne National Laboratory

CFA = Central Facilities Area

CPP = Chemical Processing Plant

NRF = Naval Reactors Facility

PER = Power Excursion Reactor

TAN = Test Area North

TRA = Test Reactor Area

2.4.2 Rocky Flats Plant

Table 3 is a list of buildings at Rocky Flats associated with waste sent to the designated area of Pit 4.

Table 3. Rocky Flats Plant generators that disposed waste in designated area of Pit 4.

Building	Name / Function
Building 123	Health Physics Laboratory
Building 331	Garage and Fire Station/Vehicle Maintenance
Building 444	A-Plant, depleted uranium and beryllium machining, plating, brazing, etching and coating, graphite mold production and cleaning
Building 771	C-Plant, Plutonium Recovery Operations
Building 774	Liquid Waste Treatment
Building 776	Assembly and Manufacturing Building/Plutonium Machining
Building 777	Assembly and Manufacturing Building/Plutonium Machining
Building 779	Plutonium Research and Development Building
Building 881	B-Plant, HEU Recovery and Manufacturing (1952 – 1966) Stainless Steel Manufacturing (1966 – 1984)
Building 883	Beryllium and Uranium Machining Facility
Building 991	D-Plant, Final Assembly Building and Production Warehouse

Waste was also transshipped through Rocky Flats to the INEEL. Those identified in WILD as associated with shipments to the Pit 4 area of interest were the Denver Research Institute (DRI) and the United States Geological Survey (USGS). The DRI sent very small amounts of radioactive materials used in chemistry classes. The only information concerning the USGS is that the USGS operated a small reactor beginning in 1969 that may have generated radioactive waste but this was after Pit 4 was closed. The WILD type description for the USGS waste is non-combustibles, scrap metal, brick, etc.

2.5 Data Sources

The draft acceptable knowledge (AK) summary report, titled *Central Characterization Project Acceptable Knowledge Summary Report for A Described Area in Pit 4 at the Idaho National Engineering and Environmental Laboratory*, was used as the primary source of process knowledge and chemical inventory information in this EDF. The AK documentation and associated references provide detailed information relating to facility histories and process operations. AK information is obtained from numerous sources including facility safety basis documentation, facility procedures, generator and storage facility waste records, and interviews with cognizant personnel. A series of working meetings were held between the authors of this EDF, other BBWI support personnel, and the AK document preparers in order to develop and document an appropriate chemical inventory for analysis in this EDF. The resulting inventory table, based on these discussions and the AK summary report, is presented as Table 4 below^a.

a. Internal correspondence between Carrie Johnson, Wastren Inc., and Brent N. Burton, *Chemical List for Waste in Pit 4, Area 1* (9/20/04).

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Table 4. List of chemicals that may be present in Area 1 of Pit 4 as determined in the development of the acceptable knowledge.

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
1,1,1-trichloroethane, TCA, Methyl chloroform, Chlorothenne, Chlorothenne NU, Chlorothenne VG	CPP-603-4H: Decontamination chemicals PER-601-1H: Combustibles (paper, etc.) PER-ORM-1H: Paper, cloth, wood, Santo wax, and empty barrels RFO-DOW-3H: Uncemented sludges RFO-DOW-4H: Combustibles RFO-DOW-6H: Filters RFO-DOW-9H: Metals RFO-DOW-12H: Particulate waste RFO-DOW-15H: Organic sludge	minor	In the oils treated in the 74A/743 sludge. Could be in combustible stream in small amounts. B123, B441, B559, B779, B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	Used for components cleaning throughout RFP. In B123, B441, B559, B771, and B881, used in laboratory operations. In B779, used in Product Physical Chemistry and in Chemistry Technology.	RF-C214, RF-C406, RF-P040, RF-P084, RF-P085, RF-U115, ARA-P009, ARA-P010, ID-P091
1,1,2-trichloroethane	N/A	trace	N/A	Detected during environmental sampling at ARA-II and ARA-III. There is no indication that it was included in the waste sent to the RWMC.	ARA-P010
1,1-dichloroethylene	RFO TAN ARA PER	trace	Radioysis product in headspace gas sampling. Possible radioysis product of 1,1,1-trichloroethane.	Detected during environmental sampling. There is no indication that it was included in the waste sent to the RWMC.	RF-C406, ARA-P009, ID-P091
1,2-dichlorobenzene	RFO	trace	Evaporated or consumed in the process, may be in combustible stream in small amounts.	For RFP wastes, noted as a possible radiolysis product of 1,1,1-trichloroethane.	RF-C214

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
1,4-dioxane	RFO TAN ARA PER	trace	Inhibitor in 1,1,1-trichloroethane that was treated in B774, 74A/743 sludge.	For RFP, 2.5% (w/w) inhibitor in 1,1,1-trichloroethane. Small volume of this chemical is present in 1,1,1-trichloroethane and a small volume of 1,1,1-trichloroethane is in the waste.	RF-C404
2-ethylenoxyethanol	RFO	trace	Consumed in the process, may be in combustible stream in small amounts. B771 liquid waste to B774, 741 sludge. Possibly bottled to 744 sludge.	In B771, used in Pu metallurgical R&D.	RF-C044, RF-P108, RF-P218, RF-U172
2,2,4-trimethylpentane	RFO	trace	unknown	In B771, no use listed for the chemical.	RF-P091
4,4-methylenebis (2-chloroaniline) MOCA	RFO	trace	Buried in 744 sludge, not in targeted waste form.	MOCA resin hardener. There is no notation in the Series 744 logbook concerning this compound in 1967, the 1966 logbook is not available.	RF-P047
Acenaphththalene	N/A	trace	N/A	This was found in sampling of the septic systems at ARA-II and ARA-III; there is no indication that this chemical was in any waste sent to the RWMC.	ARA-P010

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Acetic Acid	RFO	trace	Consumed in the process, may be in the combustible stream in small amounts. B771 liquid waste to B774, 741 sludge. B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. May have been bottled and processed in B774, 744 sludge.	In B771, Pu metallurgical R&D used in small amounts in a small volume waste stream. In B881, EU recovery used to pickle the U-235 button after the reduction step (until 1964). In B881, used in metallurgical operations (listed in 1971).	RF-C227, RF-P084, RF-P260, ARA-P008
Acetone	ARA CPP-601-5H: Organic solvents PER-601-1H: Combustibles (paper, etc.) PER-ORM-1H: Paper, cloth, wood, Santo wax, and empty barrels TAN RFO	trace	Evaporated and in combustible stream in small amounts. May have disposed of any used product to B774 for treatment, 741 and 742 sludges. Possibly processed in 744 sludge.	Used for parts cleaning and in coolant used in Pu, DU, and EU machining. In B779, used in Nuclear Joining.	RF-C044, RF-C167, RF-C176, RF-C215, RF-C406, RF-P040, RF-P084, RF-P085, RF-P108, RF-U172, ARA-P009, ARA-P010, ARA-U001, ARA-U003, ID-P091
Activated carbon	RFO	trace	Consumed in the process. Present in the 741 and 742 sludges.	In B774, used for adsorption in 1st and 2nd Stage Precipitation from 1954 to at least 1964.	RF-C096, RF-P098, RF-P108, RF-P165, RF-U111, RF-U283
Activated charcoal	ANL-W	trace	Used activated charcoal. It is not known if any was included in the waste.	A fume trap consisting of a bed of activated charcoal and AEC filters was to be used for the removal of iodine in the airstream for the fuel melt refining process at ANL-W.	ANL-W-P001
Alcohol	RFO	trace	Evaporated or in combustible stream in small amounts. B771 liquid waste to B774, 741 sludge. B123, B559, B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. May have been bottled and sent to B774, 744 sludge.	Used in B123, B559, B771, B881 laboratories.	RF-C227, RF-P068

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Aluminum metal	RFO	trace	May be contained in the debris stream. B444 and B447 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444 and B447, used in physical metallurgy. Also composited with depleted uranium and stainless steel. In B779, used in the Coatings facility as a substrate.	RF-P040, RF-P047, RF-P085
Aluminum nitrate	RFO	trace	Consumed in the process, may be in combustible stream in small amounts. B771 liquid waste to B774, 741 sludge. B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B771, was used in combination with ferrous sulfamate from at least 1965 in anion exchange to reduce plutonium in the solution to plutonium(III) and to complex any fluoride present from the dissolution process. In B881, used in an unknown process.	RF-C211, RF-C227, RF-P084, RF-P091, RF-P108, RF-P260, ARA-P002-7
Aluminum oxide	RFO	trace	Not used in a process. Dissolved refractory material carried in waste liquids processed in B774, 741 sludge. Aluminum oxide from grit blasting may be in noncombustible stream.	Used in refractory incinerators, used in grit blasting throughout RFP.	RF-C227, ARA-P008
Ammonium bifluoride	ARA RFO	trace	Chemicals used in ML-1 testing disposed prior to our timeframe.	ML-1 skid and shielding is in Pit 4; therefore, waste from ML-1 reactor development is probably not in Pit 4.	RF-C227, RF-P084, ARA-P002-7
Ammonium chloride	ANL-W	trace	B881 - Consumed in the process, may be in combustible stream in small amounts. Liquids may have been processed in B774, 742 sludge, or to the solar evaporation ponds.	In B444, used in stripping titanium coatings (1987). In B881, metallurgical operations (listed in 1971) used it in an unnamed process.	ARA-P008
			unknown	No use was identified for this chemical at ANL-W.	

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Ammonium hydroxide	RFO	trace	Consumed in the process, may be in the combustible stream in small amounts. B123, B444, B779, and B881 liquids to B774, 742 sludge, or to the solar evaporation ponds. B771 liquids to B774, 741 sludge.	In B123, used in the HP lab. In B444, used in the plating lab. In B881, metallurgical operations used it in an unnamed process (1971). In B771, Chemical Operations used it in U-233 recovery which was a limited process. In B779, used in methods development for recovering, separating, and purifying actinides from the waste streams and residues; used in chemistry technology.	RF-C211, RF-C227, RF-P040, RF-P084, RF-P091, RF-P181
Ammonium sulfate	RFO	trace	Consumed in the process, may be in combustible stream in small amounts. Any remaining in the liquid was treated in B774, 741 sludge.	Used in the peroxide precipitation process since 1953 as an alternate to sulfuric acid (for sulfate addition)	RF-P091, RF-P262
Ammonium thiocyanate	RFO	trace	Consumed in the process, may be in combustible stream in small amounts. B123 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	In B123, used in the HP lab. In B771, the major chemical in the americium recovery process from 1959 to 1975. The peroxide precipitation effluent went to anion exchange where the plutonium was removed from the americium stream. The ion column effluent containing the americium went to the ammonium thiocyanate-ion exchange process.	RF-C211, RF-P068, RF-P181, RF-P260, RF-P262
Ammonium thiosulfate	RFO	trace	Consumed in the process, may be in combustible stream in small amounts. Any remaining in the liquid was treated in B774, 742 sludge, or to the solar evaporation ponds.	In B123, analytical processes.	Abbott

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Arsenic	RFO	trace	May be present in the combustible stream. B123 liquid waste to the solar evaporation ponds or treated in B774, 742 sludge.	In B123, used in the HP lab.	RF-P181, ARA-P009, ARA-P010, ARA-U001
Ascorbic acid	RFO	trace	Consumed in the process, may be in the combustible stream in small amounts. Liquid waste to B774 for treatment, 741 sludge.	In B771, used in Np recovery.	RF-P085, RF-P091, RF-P260
Barium	ARA TAN RFO	trace	B771 liquid waste to B771, 741 sludge, B123, B559, B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. May also have been bottled with lab waste and processed as 744 sludge. INEL-unknown	Possibly used in the lab (B123, B559, B771, B881). Barium was a fission product in the fuel elements from EBR-II.	ARA-P009, ARA-P010, ARA-U001, ANL-W-P001
				Found during environmental and radionuclide sampling at ARA and TAN, not expected to be in the waste.	
Barium carbonate	RWMC	unknown	unknown	Found in sampling at the RWMC.	ID-U297
Barium fluoride	RWMC	unknown	unknown	Found in sampling at the RWMC.	ID-U297
Benzene	RFO	trace	Consumed in the process, evaporated, may be in combustible stream in small amounts. B777 and B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. Lab waste may be in 744 sludge.	In B777 (1966-1975), used in ultrasonic testing of components and as a lab reagent in B881. Also used in paints and thinners throughout RFP.	RF-C406, RF-P085, ANL-W-P009
Beryllia	ANL-W	trace	unknown	Limited waste from ANL-W to the designated area of Pit 4, should be little beryllia from this source.	ANL-W-P001

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Beryllium, Beryllium oxide	CFA-633-1H CPP-601-4H: Acidic aqueous liquid. RFO-DOW-20H: Radiation sources. TAN-607-4H: Reactor and auxiliary components from ML-1, PM-2A, and two SNAPTRAN systems. TRA-603-15H: metal (aluminum, stainless steel, zircalloy, beryllium, and cadmium). TRA-670-1H: Beryllium RFO	trace	B123, B441, B444, B447, B559, B777, B881, B883, and B991 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. In B779, cutting fines were collected and stored in a drum, then sent to B774 for disposal. In B779, fines from grinding were flushed down the process drain to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge. May be in combustible stream. Solid turnings and fines from machining coated with oil deposited in waste drums as noncombustible waste. Chips and turnings possibly cemented. Waste disposal records show "Be" in the waste type field, along with normal waste types I and V. Beryllium also may be included with disposed sources.	RFP: In B123 and B441, used in the HP lab. In B331, used in R&D processes. B444, B447, B881, and B883 cast, forged, rolled, and processed beryllium. In B559, used in laboratory operations. In B771, plutonium contaminated with beryllium was processed; in the laboratory beryllium was analyzed and used as standards. In B777, used in machining. In B779, used in the Coatings facility as a substrate. In B991, handled during final assembly.	RF-C227, RF-P065, RF-P084, RF-P085, RF-P181, RF-U038, RF-U115, RF-U124, RF-U150, ARA-P002-7, ID-P091
Bis (2-ethylhexyl) phthalate DOP	ARA TAN RFO	trace	Testing of HEPA filters at RFP in this timeframe was not as routine as it was in later years. In combustible and CWS/HEPA filter streams. Any liquid may have been treated in B774, 741, 742, or 744 sludge.	Used for testing CWS/HEPA filters. Found during environmental sampling of the underground tanks at TAN and at ARA.	RF-U152, ARA-P009, ARA-P010

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Boric acid	ANL-W PER RFO	trace	In B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In the B881 metallurgical operations, boric acid is listed without a use (1971). At ANL-W, boric acid was in the industrial wastewater from an unknown process. At SPERT III, boric acid was used as a neutron poison to shut the reactor down in an emergency.	RF-C227, ARA-P008, PER-P006
Brass metal	RFO	trace	May be in the debris stream in small amounts.	In B444, used in physical metallurgy.	RF-P085
Bromoform	unknown	trace	unknown	This information came from an environmental sampling effort at ARA. There is no indication that this was in the waste sent to RWMC.	ARA-P010
Butanol	RFO-DOW-3H: Uncemented sludges	trace	Evaporated, may be in combustible stream in small amounts. B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. May have been bottled and shipped to B774, 744 sludge.	A component of Dychem penetrant, used in B444 production area. Used to react lithium metal.	RF-P084
Butyl acetate	RFO	trace	Evaporated, possibly in combustible stream in small amounts. B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. May have been bottled to B774, 744 sludge.	A component of Dychem penetrant, used in B444 production area.	RF-P084
Cab-O-Sil®	RFO	very trace	Included in the early 74A/743 sludges. Was replaced by Johns-Manville MicroCell(E) very early in the process	In B774, used to solidify oils and coolant in the early processing of 74A/743 sludge. Replaced by Johns-Manville MicroCell(E)	RF-C015, RF-P047, RF-U115

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Cadmium metal, cadmium oxide cadmium salts	PER-601-1H: Combustibles (paper, etc.) RFO-DOW-3H: Uncemented sludges TRA-603-15H: metal (aluminum, stainless steel, zircalloy, beryllium, and cadmium) RFO	minor	B123, B444, B881, B883 liquid wastes to B774, 742 sludge, or to solar evaporation ponds. Alloyed chips and turnings possible in debris waste, may have been cemented. B771 cadmium salts consumed in the process, liquid waste to B774, 741 sludge. B881 cadmium salts consumed in the process, liquid waste to B774, 742 sludge, or to the solar evaporation ponds	In B123, used in the HP lab. In B444, cyanide cadmium plating was an R&D or lab scale process until 1980's. B444 and B883, rolled, shaped, and alloyed cadmium. In B771 and B881, cadmium salts used as a neutron poison in dissolution. In B881, cadmium plating of uranium parts. In B881, cadmium oxide used in an unknown process.	RF-C211, RF-C227, RF-P064, RF-P084, RF-P085, RF-P091, RF-P181, ARA-P002-7, ARA-P009, ARA-U001, ANL-W-P001
Calcium metal, calcium-zinc alloy	RFO	trace	Consumed in the reaction. Some residual calcium metal may remain in the sand, slag, and crucible waste; usually processed through dissolution. Calcium-zinc alloy from DOR process was process through dissolution or may have been sent offsite for processing. B771 liquid waste to B774, 741 sludge. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B771, granular calcium metal used in thermite reduction (Pu, Np, and U-233). In B779, calcium metal and calcium-zinc alloy were used in the DOR process which was in the R&D stage in 1967.	RF-C211, RF-P084, RF-P091, RF-P260, RF-P262
Calcium chloride	RFO	minor	Consumed in the process. B771 liquid waste to B774, 741 sludge. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B771, direct oxide reduction which was R&D scale in 1967. In B774, used as a reagent in 1st and 2nd stage processing throughout this timeframe. In B779, used in chemistry technology.	RF-P040, RF-P047, RF-P108, RF-P260, RF-P262, RF-U115, RF-U136

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Calcium fluoride	RFO	trace/ minor	Trace amounts remaining on waste graphite and in SS&C. Graphite scarlings and SS&C usually processed through dissolution to recover the metal. Minor amounts in the SS&C that was not processed through recovery. B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	In B444, used to coat beryllium graphite molds. In B771, produced in all thermite reduction operations (Pu, EU, Np, U-233).	RF-P091, RF-P262, RF-U115
Calcium hydroxide	RFO	trace	Consumed in the process. Would be in the 741, 742, and 744 sludges.	In B774, used as an alternate for potassium hydroxide and sodium hydroxide to neutralize acids and acidic wastes.	RF-P108
Calcium nitrate	RFO	trace	Unknown use in B771. B444 waste generation, not in our timeframe.	In B771, no indication as to the use. In B444, calcium nitrate was used as an etching solution in the 1980's.	RF-P084, RF-P091
Calcium oxide, Lime, Quicklime	RFO	trace	Could be present in the 744 sludge. May be present in the 741 and 742 sludge.	In B774, used for neutralization of acids prior to mixing into 744 sludge. May have been used to neutralize other acids.	RF-P047, RF-P260, RF-P262, RF-U115, RF-U136
Calcium silicate	RFO	major	Mixed with the organic liquid waste (74A/743 sludge) and allowed to set up in the drum. Also used as an absorbent in the drums that were emptied while processing the waste oil/solvent mixture. Possibly also used in other areas for liquid absorbent.	Synthetic calcium silicate [Johns Manville Microcell(E)] was used in the Organic Setups process.	RF-P108, RF-P260, ID-U297
Carbon disulfide	RFO	trace	Consumed in the process, possibly in the combustible stream in small amounts. B123 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B559, B881 liquid waste to B774, 742 sludge, or to the solar evaporator ponds. B771 liquid waste to B774, 741 sludge.	Used as a laboratory solvent (B123, B559, B771, B881) and detected in headspace gas sampling.	RF-C406

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Carbon tetrachloride	ANL-752-1H: Routine dry active waste CPP-601-5H: Organic solvents RFO-DOW-12H: Particulate waste RFO-DOW-15H: Organic sludge RFO-DOW-3H: Uncemented sludges RFO-DOW-4H: Combustibles RFO-DOW-6H: Filters RFO-DOW-9H: Metals	major	In the oils treated in the 74A/743 sludge. Possibly some set up in 744 sludge. B123, B441, B559, B779, B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	Used throughout the plutonium buildings in coolant, solvent, and in cleaning. Carbon Tetrachloride mixed with oils treated in B774, B123, B441, B559, B771, B881; used in laboratory operations. In B779, used in Chemistry Technology and Plutonium Physical Metallurgy.	RF-C211, RF-C214, RF-C233, RF-C234, RF-P040, RF-P047, RF-P084, RF-P085, RF-U143, RF-U188, RF-U201, ARA-P009, ID-P091
Caustic soda	RFO	trace	Could be present in the 744 sludge. May be present in the 741 and 742 sludge.	In B774, used for neutralization of acids prior to mixing into 744 sludge. May have been used to neutralize other acids.	RF-P047, RF-U115
Cesium	ANL-W	In radiological table	unknown	Cesium was a fission product in the fuel elements from EBR-II.	ANL-W-P001
Chlorobenzene	RFO	trace	unknown	B771, use was not specified.	RF-P091
Chloroacetic acid	RFO	trace	Evaporated and may be in combustible stream in small amounts. Used liquid may have been disposed to B774 for treatment, 742 sludge, or transferred to the solar evaporation ponds.	Cee Bee solvent component, used in the production area of B444, used in B123 lab.	RF-P085, RF-P181
Chloroform, Trichloromethane	ANL-752-1H: Routine dry active waste RFO	trace	Evaporated and may be in combustible stream in small amounts. B444, B559, B779, and B883 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	In B444 and B883, used in uranium parts cleaning and inspection. In B559, used in laboratory operations. In B771, used in the analytical and mass spec. labs after 1967. In B779, used in chemistry technology. Used by carpenters throughout RF to join Plexiglas.	RF-C214, RF-C406, RF-P040, RF-P084, RF-P085, ARA-P010

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Chromic Acid	RFO	trace	Consumed in the process or neutralized when received in B774, then processed to 741 sludge.	In B771, used in Pu metallurgical R&D.	RF-C044, RF-P108, RF-U172
Chromium metal	CPP-601-4H: Acidic aqueous liquid RFO	trace	May be present in the debris stream. B123, B444, B559, B776, B779 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds.	In B123, used in the HP lab. In B444, chromium plating was performed on an R&D or lab scale basis until the 1980's. In B776, a chromium antimicrobial was used to treat the Kathene solution (see lithium chloride). In B779, used in chemistry technology and physical metallurgy.	RF-C227, RF-P040, RF-P084, RF-P085, RF-P181, RF-U208, ARA-P008, ARA-P009, ARA-P010, ARA-U001
Chromium chloride, chromium nitrate, chromium oxide, chromium potassium sulfate, chromium sulfate, chromium trioxide (Kathene)	RFO	trace	May be present in the combustible stream in small amounts. B559 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B776/777 and B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B559, used in the laboratory process. In B776/777, a component of Kathene used in the air drying system in the buildings. In B881, used in an unknown process.	RF-C227, RF-P085
Citric acid	RFO	trace	Consumed in the process. Enriched uranium processing was not done in our time-frame (ended 1964).	In B881, used in enriched uranium recovery process.	RF-P084, RF-P260
Copper metal	RFO	trace	May be present in the debris stream in small amounts. B444, B447, B777, and B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444 and B447, used in physical metallurgy. In B777, used in assembly operations. In B779, used in physical metallurgy.	RF-P040, RF-P085, RF-U038, RF-U124
Copper sulfate	RFO	trace	Consumed in the process or in combustible stream in small amounts. Any liquids treated in B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in Nuclear Joining and in the Coating Facility.	RF-P040, PER-P006

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Cresol (-p,-o,-m)	ARA TAN	trace	N/A	This was found during environmental sampling at ARA and TAN. There is no indication that there is any in Pit 4.	ARA-P009, ARA-P010
Cupric sulfate	RFO	trace	B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B881, this chemical was listed on metallurgical operations chemical list with no known use included (1971).	RF-C227
Cyanide, sodium cyanide, potassium cyanide, ferrocyanide	RFO	trace/ minor	B444 liquid waste to B774, 742 sludge or to solar evaporation ponds. The 1967 742 sludge logbook notes several instances of “cyanide pellets” and “KCN” in the sludge drums, all after our timeframe for Pit 4 (1st instance is August 1967).	In B444, cyanide was used in an R&D or lab scale plating operations (cadmium, chromium, and gold) from the mid-60’s to the 1980’s. B881 used cyanide plating prior to enriched uranium operations being curtailed. B883, a component of Developer Rack Cleaner (sodium ferrocyanide).	RF-P047, RF-P084, ANL-W-P009
Cyclohexane	RFO	trace	unknown	Use was not identified in B771.	RF-C044, RF-P108, RF-U172
DCHP (dicesium hexachloro plutonate)	RFO	trace	May be present in the debris stream. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in R&D operations.	RF-P040
Dibutyl carbitol	RFO	trace	B881 enriched uranium processing was shutdown in 1964. In B771, consumed in the process. B771 liquid waste to B774 for treatment 741 sludge.	In B881, used in uranium solvent extraction. In B771, used in special recovery process. B771 enriched uranium recovery.	RF-P084, RF-P260

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Diethyl phthalate	NA	trace	N/A	This was found in environmental sampling at ARA; there is no indication that it was in the waste sent to the RWMC.	ARA-P010
Dimethylamine	RFO	trace	Consumed in the process. May be in combustible stream. Liquid waste treated in B74, 742 sludge, or to the solar evaporation ponds.	In B779, used in chemistry technology.	RF-P040
Di-n-butyl phthalate	NA	trace	N/A	This was found in environmental sampling at TAN; there is no indication that it was in the waste sent to the RWMC.	ARA-P009
Dodecane	RFO	trace	Consumed in the process. Any liquid treated in B774, 742 sludge. Possibly in 744 sludge.	In B771, used in special recovery to recover uranium in a solvent extraction process. In the 1950's, Gulf BT was used in plutonium solvent extraction in B771, not dodecane.	RF-P091
EDTA (Versenes)	RFO	trace	May be in combustible stream. Processed in B774, 742 and 744 sludge (as solidified "KW").	A component of the cleaning agent "KW", used throughout RFP in the 1950's and 1960's for decontamination.	RF-P026, ID-U297
Epoxy glues	RFO	trace	May be in combustible and/or noncombustible stream.	Epoxy glues used throughout the plantsite. In B881, used in special projects.	RF-P084
Erbium oxide/nitrate	RFO	trace	NA - Not used until 1985.	In B444, used to coat graphite molds prior to use (1985).	RF-P084

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Ethyl alcohol, Ethanol	CPP-601-5H: Organic solvents TAN RFO	trace	Evaporated or may be in combustible stream. B122 liquid waste to the solar evaporation ponds. B444, B776/777, B779, and B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. May have been bottled and sent to B774, 744 sludge.	In B122, used for personnel decontamination (small volume generator). In B444, B776/777, B779, and B881, used to clean beryllium parts. In B779, used in Nuclear Joining and in Product Physical Chemistry. In B881, used in special projects.	RF-C215, RF-P084, RF-P085, ARA-U003, ID-P091
Ethyl acetate	NA	trace	N/A	May be in the combustible stream from TAN. At TAN, used as a degreaser.	ARA-P010
Ethyl benzene	TAN RFO	trace	Evaporated and may be in combustibles stream. May have disposed of used product down drain to B774, 741 and 742 sludges. May have been bottled and processed in B774, 74A/743 or 744 sludge.	Component of paints, thinners, and strippers.	ARA-P009
Ethylene dibromide	RFO	trace	Evaporated and may be in combustibles stream. B559 and B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge. May have been bottled and processed in B774, 74A/743 or 744 sludge.	In Bldgs. 559, 771, and 881 laboratories, used as a solvent.	RF-C214
Ethylenedichloride	RFO	trace	Evaporated and may be in combustibles stream. B559 and B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge. May have been bottled and processed in B774, 74A/743 or 744 sludge.	In Bldgs. 559, 771, and 881 laboratories, used as a solvent.	RF-C214

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Ethylene Glycol	RFO	trace	Consumed in the process, may be in combustible stream. B771 liquid waste to B774, 741 sludge. B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. May have been bottled and processed in B774, 74A/743 or 744 sludge.	In B771 and B881, used in metallographic sample preparation. Used by maintenance throughout RFP.	RF-P084, RF-P218, RF-U201, ANL-W-P009
Ferric sulfate	RFO	minor	Consumed in the process. Both 741 and 742 sludges will contain large amounts of ferric sulfate.	Large quantities of this chemical were used in 1st and 2nd Stage precipitation in B774.	RF-C096, RF-P098, RF-P108, RF-P165, RF-P260
Ferrite	RFO	trace	Consumed in the process. Any liquid waste processed in B774, 742 sludge, or sent to the solar evaporation ponds.	In B779, used in waste treatment R&D.	RF-P040
Ferrous sulfamate	RFO	trace	Consumed in the process. Any liquid processed in B774, 741 sludge.	In B771, was used in combination with aluminum nitrate from at least 1965 into the 1980's in anion exchange to reduce plutonium in the solution to plutonium(III) and to complex any fluoride present from the dissolution process. Also used in B771 in Np anion exchange for same purpose.	RF-P084, RF-P091, RF-P260
Ferrous sulfate	RFO	trace	Consumed in the process. Any liquid processed in B774, 741 sludge.	In B771, used in Np recovery. Ferrous sulfate was not used in B774 after 1959.	RF-C211, RF-P260, RF-U048, RF-U111, RF-U283
Fluoranthrene	ARA	trace	N/A	This was found in environmental sampling at ARA; there is no indication that it was in the waste sent to the RWMC.	ARA-P010

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Fluorene	NA	trace	N/A	This was found in environmental sampling at ARA; there is no indication that it was in the waste sent to the RWMC.	ARA-P010
Fluosilicic acid	RFO	trace	Reacted with aluminum nitrate and heat to form aluminum fluoride and silica slime that coated process lines, plugged filters, and coated ion exchange resin. May be present in small amounts in combustible and noncombustible stream.	In B771, formed in anion exchange.	RF-P084, RF-P264
Formaldehyde	RWM/C RFO	trace	INEL – unknown	This was found in sampling at RWM/C. In B559, used in laboratory operations.	RF-P085, ID-P091, ID-U297
Formic acid	RFO	trace	May be present in the combustible stream in small amounts. B559 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	Evaporated and may be in combustible stream. B123 and B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. May have bottled waste solution to B774, 744 sludge.	RF-P085, RF-P181
Freon, Freon-12 Freon-TF (also Freon-113, Freon TCA, and 1,1,2-trichloro-1,2,2-trifluoroethane), Freon MF Genesolv-D Freon TB (a trichlorotrifluoro ethane-ethylene glycol monobutyl ether mixture)	RFO-DOW-3H: Uncemented sludges RFO-DOW-4H: Combustibles RFO-DOW-6H: Filters RFO-DOW-9H: Metals RFO-DOW-12H: Particulate waste	minor	Evaporated and may be in combustible stream in small amounts. B771 liquid waste to B774, 741 sludge. B559, B779, B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. Some also treated in 743 sludge. Some may have been bottled and treated in B774, 744 sludge.	Used in most areas at RFP in varying amounts. In B559, B771, B881 laboratories. In B779, used in Nuclear Joining , Plutonium Physical Metallurgy, and in Product Physical Chemistry.	RF-C211, RF-C214, RF-C406, RF-P040, RF-P084, ARA-P010

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Gallium metal	RFO	trace	May be present in the debris stream in small amount. Alloyed with plutonium.	In B779, used in R&D operations.	RF-P040
Glycerol	RFO	trace	Consumed in the process, may be present in the combustible and noncombustible stream in small amounts. Any liquid stream to B774 for treatment, 741 sludge.	In B771, used in the preparation of metallurgical samples for R&D.	RF-U201
Gold	RFO	trace	B444 and B779 liquid waste to B774, 742 sludge, or to solar evaporation ponds. Possibly a small amount in the debris stream.	In B444, used in plating and alloying. In B779, used in the Coating facility.	RF-P084, RF-P085
Hexane	RFO	trace	Consumed in the process, may be present in the combustible stream in small amounts. B771 liquid waste to B774, 741 sludge. May be present in Series 744.	In B771, used as laboratory reagent.	RF-P084
Hexone	CPP	trace	There is no indication as to how much was disposed or whether it was placed in the waste that went to Pt 4.	Used in spent fuel processing at CPP.	INTEC-P001
Hydrazine	RFO	trace	Consumed in the process, may be present in the combustible stream in small amounts. B771 liquid waste to B774, 741 sludge. B779 and B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B771, Np recovery used small amounts of hydrazine as a reducing agent. In B779, used in process development and methods development for recovery processes. In B881, process using hydrazine unknown; may have been laboratory.	RF-C227, RF-P040, RF-P085, RF-P260, PER-P006
Hydrochloric acid	RFO	trace	Consumed in the process, may be present in combustible stream in small amounts. Hydrochloric acid waste generated in B771 to B774 where it was neutralized, then processed to 741 sludge. B123 and B779 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds. Most hydrochloric acid waste was bottled and sent to B774, 744 sludge.	In B123, used in the HP lab. In B771, used in plutonium recovery processing. In B779, used in Chemistry Technology and in Nuclear Joining.	RF-C211, RF-P040, RF-P084, RF-P091, RF-P181, RF-P260, RF-U172, RF-U208, ARA-P002-7, ARA-U003

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Hydrofluoric acid	CPP-601-4H: Acidic aqueous liquid RFO	trace	Consumed in the process, may be present in the combustible and in the CWS/HEPA filter streams in small amounts. B123, B779, and B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	In B123, used in the HP lab. In B771, used in plutonium recovery operations. In B779, used in the Nuclear Joining, in Plutonium Physical Metallurgy, and in the Coatings facility. In B881, used in an unknown process. Used at CPP to dissolve reactor fuel. Not anticipated to be in Pit 4.	RF-C227, RF-P040, RF-P084, RF-P091, RF-P108, RF-P181, RF-P260, ARA-P002-7, ARA-U003, ID-P091, INTEC-P007, PER-P006
Hydrogen peroxide	RFO	trace	Consumed in the process. B122 liquid waste went to the solar evaporation ponds. B444 and B881 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid wastes to B774, 741 sludge.	In B122, used for personnel decontamination. In B444, used in ultrasonic etching. In B881, enriched uranium recovery was shut down prior in 1964. In B771, large volumes of hydrogen peroxide were used.	RF-C211, RF-P068, RF-P084, RF-P085, RF-P091, RF-P108, ARA-P002-7
Hydroiodic acid	RFO	trace	Consumed in the process. Liquid waste treated in B774, 741 sludge.	In B771, used in Np anion exchange and in Np precipitation.	RF-C044, RF-P108, RF-U172
Hydroquinone	ANL-W	trace	unknown	ANL-W - no use was identified.	ARA-P008
Hydroxylamine hydrochloride	RFO	trace	Consumed in the process. Liquid waste treated in B774, 741 sludge.	In B771, used in Np precipitation.	RF-C044, RF-P108, RF-U172
Hydroxylamine nitrate	RFO	trace	Consumed in the process. Liquid waste treated in B774, 741 sludge.	In B771, used in Np precipitation and anion exchange.	RF-P085, RF-P260
Iodine, elemental iodine	RFO	trace	Consumed in the process, may be in the debris stream in small amounts. B771 liquid waste to B774, 741 sludge. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B771, used in thermite reduction (Pu). In B881, used in thermite reduction (HEU). In B779, used in R&D operations.	RF-P091, RF-P040, RF-P260, ANL-W-P001

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Isopropyl alcohol, Isopropanol	RFO	trace	Evaporated and may be in combustible stream in small amounts. B122, waste to the solar evaporation ponds. B123, B776/777, B779, B881, and B991 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge. May have been bottled and processed to 744 sludge.	In B122, used for personnel decontamination. Used for analytical purposes in the laboratory in B123, B771, and B881. In B444, used to clean depleted uranium parts prior to assembly and welding and brazing. In B991, used during inspection of completed parts. In B771, used in Pu metallurgical R&D.	RF-C044, RF-C406, RF-P040, RF-P084, RF-P085, RF-P108, RF-P181
Kerosene	RFO CPP	trace	unknown	B444 and B779, uses not specified in. Kerosene was used extensively in the solvent extraction process at CPP.	RF-C215, ANL-W-P009, ARA-P008
Lead oxide, lead acetate, lead chloride, lead powder	RFO	trace	May be present in the debris stream in small amounts. B559 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B559, used in laboratory operations.	RF-P085

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Lead metal, lead oxide, lead-based paint	CFA CPP NRF RFO	minor	May be present in the debris stream. B123, B441, B444, and B447 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	Shielding, lead bricks, lead sheets, lead turnings, lead glovebox parts, leaded glass, lead-based paint, welding rods. In B123 and B441, used in the HP lab. B444 physical metallurgy and in plating operations. In B447, used in casting and back machining.	RF-P047, RF-P084, RF-P085, RF-P091, RF-P181, RF-U115, RF-U124, RF-U167, ANL-W-P009, ARA-P002-7, ARA-P009, ARA-P010, ARA-U001, ID-P091
Lead fluoroborate	RFO	trace	May be present in the combustible stream in small amounts. B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	Used in physical metallurgy and in plating operations in B444.	RF-P085
Lithium metal, lithium salts	RFO	trace	B444, B777, B779, B881 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds. There was a lithium disposal process (reactive metals disposal) for non- or low-contaminated lithium. Coolants may have been bottled to B774, 74A/743 or 744 sludge.	In B777, B779, and B881, lithium metal fabrication was performed as special order work in 1966. In B444, lithium salt fabrication was performed manner similar to depleted uranium.	RF-P064, RF-P084, RF-U046
Lithium carbonate	RFO	trace	Salts were drummed in B883 and shipped to RWMC.	Used extensively in B883 prior to rolling enriched and depleted uranium.	RF-P084, RF-P260
Lithium chloride (Kathene)	RFO	trace	Liquid waste to B774, 742 sludge.	Used in the air drying system in B776/777.	RF-P084
Lithium hydride	RWMC	unknown	unknown	Found in sampling at the RWMC.	ID-U297
Lithium perchlorate	RFO	trace	Consumed in the process, may be in combustible stream in small amounts. Any liquids to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in chemistry technology in a study of the reaction plutonium and xenon trioxide.	RF-U208

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Magnesia, magnesium oxide	Magnesium oxide: associated with RFO-DOW-3H, uncemented sludge	trace	Consumed in the process, may be present in the debris stream in small amounts. B771 liquid waste to B774, 741 sludge. B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B771, magnesium oxide sand/crucible was used in Pu thermite reduction. In B881, used for an unknown process.	RF-C227, RF-P084, RF-P091, RF-P260, ANL-W-P001
Magnesium metal, powdered magnesium	RFO	trace	Consumed in the process, may be present in the debris stream in small amounts. B771 liquid waste to B774, 741 sludge. B444 and B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444, used in physical metallurgy. In B771, magnesium metal is listed for use in an unnamed process (1971). In B771, powdered magnesium was used in thermite reduction and magnesium metal was used as part of the pyrotechnic initiators in Pu thermite reduction (1972/73). In B779, magnesium was used in R&D Operations	RF-C211, RF-P040, RF-P084, RF-P085, RF-P091, RF-P262, ID-P091, PER-P011, PER-P027
Magnesium chloride	RFO	trace	Consumed in the processes, may be present in the debris stream in small amounts. Salts from the molten salt process were treated in americium recovery in B771. Liquid waste to B774, 741 sludge. Waste from electrorefining was processed through plutonium recovery operations in B771. Liquid waste to B774, 741 sludge.	In B776, magnesium chloride used in molten salt extraction and in electrowinning.	RF-P260, RF-P262
Magnesium perchlorate	RFO	trace	Consumed in the process, may be in combustible stream in small amounts. Spent scrubber solution was treated in B774, 741 sludge.	Used in the laboratory scrubber solution in B771.	RF-P106
Magnesium sulfate	RFO	trace	Consumed in the process. Present in the 741 and 742 sludges in fairly large quantities, depending on the needs of treatment.	B774, reagent used in 1st and 2nd Stage Precipitation processes.	RF-P047, RF-P108, RF-P260, RF-P262, RF-U115, RF-UI36, ARA-P008

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Magnesium zirconate	unknown	trace	Liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	B881, no use was identified.	RF-C227
Magnesium – zinc alloy	ANL-W	trace	unknown	There is no indication that any of this metal was in the waste sent to the RWMC.	ANL-W-P001
Malonic acid	RFO	trace	Was consumed in the process when it was used (ended in 1964).	In B881, used in enriched uranium recovery precipitation operations (ended 1964).	RF-P084, RF-P260
Mercury	RFO-DOW-3H: uncemented sludge RFO	trace/ minor	B123, B441, B444, B779 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds. There are several instances of spills and cleanups involving mercury. Possibility that this is in the debris and combustible streams in small amounts. Bottled mercury may be in the 742 sludge.	Used in plant instruments such as thermometers and barometers, and in plant machinery, mercury switches, welder contacts, in joining, and in experimental apparatus. In B123 and B441, used in the HP lab. In B444, used in physical metallurgy. In B779, used in an unknown process.	RF-P084, RF-P085, RF-P181, RF-U152, ANL-W-P009, ARA-P009
Mercury nitrate	RFO	trace	Consumed in the process, may be present in the combustible stream in small amounts. B559 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B559, used in laboratory operations.	RF-P085
Methyl alcohol, Methanol	RFO-DOW-3H: Uncemented sludges	trace/ minor	Evaporated and may be in combustible stream in small amounts. B123, B444, B559, B779, B881 liquid waste treated in B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge. May have been bottled and processed to 744 sludge.	B123, B559, B771, B881, used in the lab. In B444, used in Joinings and Coatings. In B779, used in the Coatings facility and in Product Physical Chemistry.	RF-C406, RF-P040, RF-P181, ARA-P010, ARA-U003, ID-P091
Methyl Cellosolve	RFO	trace	Should not be in our waste, used after 1967.	B771 analytical and mass spec. laboratories, after 1967.	Abbott

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Methyl ethyl ketone, 2-butanone, MEK	PER-601-1H: Combustibles (paper, etc.) RFO	trace	May be in combustible stream in small amounts. May have been treated in B774, 741 and 742 sludge. May have been bottled and sent to B774, 744 sludge.	Common constituent in paint thinner used throughout RFP. In B779, used in Physical Metallurgy and Nuclear Joining.	RF-C406, RF-P040, ID-P091
Methyl isobutyl ketone	CPP-601-5H: Organic solvents RFO	trace	May be in combustible stream in small amounts. May have been treated in B774, 741 and 742 sludge. May have been bottled and sent to B774, 744 sludge.	Common constituent in paint thinner used throughout RFP.	RF-C407, ARA-P010, ID-P091
Methyl naphthalene	NA	trace	N/A	Found during environmental sampling at ARA. No indication that this was disposed in the waste stream.	ARA-P010
Methylene chloride, dichloromethane	RFO-DOW-3H: Uncemented sludges RFO-DOW-4H: Combustibles RFO-DOW-6H: Filters RFO-DOW-9H: Metals RFO-DOW-12: Particulate waste	trace	May be present in combustible stream in small amounts. B771 liquid waste to B774, 741 sludge. B123, B441, B559, B779, B881 waste piped to B774, 742 sludge, or to the solar evaporation ponds. May have been bottled with lab waste to B774, 744 sludge.	B123, B441, B559, B771, B881, used in sample preparation and analysis. In B779, used in Physical Metallurgy and Nuclear Joining. Component of paint and strippers used throughout RFP.	RF-C214, RF-C406, RF-P040, RF-P084, RF-P085, RF-U115, ARA-P009, ARA-P010, ARA-U003
Molybdenum metal	RFO	trace	May be present in the debris stream in small amounts. B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444, used in physical metallurgy and in alloying (ZPPR).	RF-P085
Monel	RFO	trace	May be present in the debris stream. B777 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds.	In B777, used in assembly operations.	RF-U038, RF-U124
Naphthalene	ARA TAN	trace	N/A	Found during environmental sampling at TAN and ARA. No indication that this was included in any of the waste sent to RWMC.	ARA-P009, ARA-P010

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Nickel metal	RFO	trace	May be present in the debris stream in small amounts. B444 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds.	In B444, used in parts casting and alloying.	RF-P085
Nickel powder, nickelous chloride, nickel nitrate, nickel oxide	RFO	trace	May be present in small amounts in the combustible stream. B559 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B559, used in laboratory operations.	RF-P085
Nickel carbonyl	RFO	trace	May be present (as nickel) in combustible and noncombustible streams in small amounts. There is a small possibility that unvented nickel carbonyl gas cylinders may be in the waste from B771, B777, and B779.	Nickel carbonyl was used for nickel plating at least until the late 1960's in B771, B777, and B779.	RF-P264, RF-U042, RF-U046
Nickel chloride	RFO	trace	Consumed in the process. B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444, this was used in parts plating.	RF-P084
Nickel sulfate crystals	RFO	trace	Consumed in the process. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in chemistry technology.	RF-P085
Niobium metal	RFO	trace	Present in the debris stream in small amounts. B447 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B447, used in physical metallurgy. Alloyed with depleted uranium.	RF-U115

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Nitric acid	CFA-646-2H: NF and HNC3 liquid waste CPP-601-4H: Acidic aqueous liquid OFF-GDA-1H: Fuel fabrication items, laboratory equipment, activated metal, and irradiated fuel RFO-DOW-6H: filters RFO	minor	B771 liquid wastes to B774 where they were neutralized and processed to 741 sludge. B123, B559, B779, B881, and B883 liquid waste to B774 where they were neutralized and processed to 742 sludges, or were sent to the solar evaporation ponds. May be in combustible stream in small amounts. May be present in CWS/HEPA filter stream in small amounts. May have been bottled and processed to 744 sludge.	Used throughout RFP. In B123, used in the HP lab. In B559, used in lab analysis. In B771: used in dissolution in various normalities; used in anion exchange in various normalities; used in leaching operations in various normalities; used in R&D operations in various normalities; used in lab analysis. In B779, used in Chemistry Technology, Plutonium Physical Metallurgy, and the Coatings facility. In B881: used in OY leach operations; used in lab analysis. In B883, used in cleaning and degreasing.	RF-C211, RF-C227, RF-P040, RF-P068, RF-P084, RF-P085, RF-P091, RF-P108, RF-P181, RF-P260, RF-U143, ARA-P002-8, ARA-U003, PER-P006
Nitrobenzene	RFO-DOW-15H: organic sludge RFO	trace	May be present in combustible waste in small amounts. Processed in B774 to 741 and 742 sludge. Possibly bottled and processed to 74A/743 or 744 sludge.	In B123, B559, B771, B881, used in lab analysis.	ID-P091, ID-U297
Nitrocellulose, Collodion	RFO-DOW-4H: paper, rags, plastic. Clothing, cardboard, wood, and polyethylene bottles	trace	May be present in combustible stream in small amounts. Liquid waste to B774, 742 sludge, or solar evaporation ponds. Possible formation on combustibles involved with nitric acid.	In B444, component of Dykem penetrant, used in production areas.	RF-P047, ARA-U003, ID-P091, ID-U297
Organic acids	RFO	trace	May be present in combustible stream in small amounts. Bottled lab waste sent to B774, 744 sludge. B123, B559, B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	B123, B559, B771, B881, used in lab analysis.	HDT

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Organophosphates	RFO	trace	May be present in combustible stream in small amounts. Bottled lab waste sent to B74, 744 sludge. B123, B559, B881 liquid waste to B74, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	B123, B559, B771, B881, used in lab analysis.	HDT
Oxalic acid	RFO	trace	Consumed in the process, may be present in the combustible stream in small amounts. B771 liquid wastes to B74, 741 sludge. B123, B779, B881 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds.	B123, B771, B779, B881 laboratories, used as a reagent. In B771, used in oxalate precipitation for americium recovery (1962 to 1980's). In B779, B881, and B991, used in metallography for etching. In B779, used in Nuclear Joining and in the Coating facility.	RF-C227, RF-P040, RF-P084, RF-P091, RF-P181, RF-P260
Palladium	RFO	trace	May be in the debris stream. B771 liquid waste to B774, 741 sludge. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B771, used to make shadowed replicas in plutonium Metallurgical R&D. In B779, used in the Coatings facility.	RF-P040, RF-U202
Parafomaldehyde	ANL-W	trace	unknown	Use was not identified.	ARA-P008

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Polychlorinated biphenyl (PCB)	RFO-DOW-15H: Organic sludge	trace	May be present in the combustible and debris streams. Possibly present in 74A/743 sludge and 744 sludge. The debris materials from RFP may contain PCB-containing fluorescent light ballasts, circuit breakers, switch gear, synthetic rubbers, plastics, paints, varnishes, printing ink, paper adhesives, and asphalt. The use of paper containing PCBs at RFP was not discontinued until the 1970's.	It is believed all TRU-contaminated PCB oils were stored at the RFP with other organic wastes (carbon tetrachloride, machining oils, etc.) at 903 Pad until the organic waste solidification process at the RFP was initiated in 1966. An unknown portion of the 743 Series sludge that were shipped to the INEEL between 1966 and 1970 contain an unknown amount of PCB contaminated material.	RF-C058, RF-C405, RF-P047, RF-P084, RF-U401, ARA-P009, ARA-U003, ID-U297
Perchloric acid	RFO	trace	May be in combustible stream in small amounts. B123 and B779 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge. Possibly bottled waste to B774, 744 sludge.	In B123 laboratory used as a laboratory reagent. In B771 and B779, used in R&D operations.	RF-P106, RF-P181, RF-U208
Phenanthrene	N/A	trace	N/A	Found during environmental sampling at ARA. No indication that this was included in any of the waste sent to RWMC.	ARA-P010
Phosphoric acid	RFO	trace	Consumed in the process. May be in combustible stream in small amounts. B771 liquid waste to B774, 741 sludge. B444, B779, and B881 liquid waste to B774, 742 sludge or solar evaporation ponds.	In B771, used in Pu metallurgical R&D. In B444, used for etching in physical metallurgy and in sample preparation. In B779, used in R&D and in Nuclear Joining and in Coating operations. In B881, used for parts cleaning, etching, and sample preparation.	RF-P040, RF-P084, RF-P085, RF-P091, RF-P218, RF-U201, ARA-P002-7

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Phenol	RFO	trace	May be in combustible stream in small amounts. Any liquids would be treated in B774, 742 sludge, or sent to solar evaporation ponds.	In B444, component of Cee Bee solvent, used in the production area.	RF-P085, RF-P181
Phenyl methylsiloxane	RFO	trace	May be in combustible stream in small amounts. B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444, component of Dykem penetrant, used in the production area.	RF-P047, ARA-U003, ID-P091, ID-U297
Platinum	RFO	trace	May be in the debris stream in small amounts. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in the Coatings facility.	RF-P040
Portland cement	RFO	minor/major	Used as an absorbent. Used in 741 and 742 sludges. Used in 744 sludge, in combination with magnesia cement. Not used in Series 74A/743 sludge.	Used as an absorbent throughout RFP.	RF-P260
Potassium carbonate	RFO	trace	Salts were drummed in B883 and shipped to RWMC	Used extensively in B883 prior to rolling enriched and depleted uranium.	RF-P084, RF-P260
Potassium chloride	RFO-DOW-17H: Evaporator salts RFO	trace	Consumed in the process. Most of the salts were processed to recover americium and/or plutonium. Some may be present in the debris waste. B771 liquid waste to B774, 741 sludge. B776/777, B779, and B881 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds.	Used in the pyrochemical processes, along with magnesium and sodium chloride, in B771/776/779. Used in an unknown process in B881.	RF-C227, RF-P260, RF-P262, ID-P091
Potassium dichromate	RFO-DOW-17H: Evaporator salts RFO	trace	Consumed in the process, may be present in combustible stream in small amounts. B779 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in physical metallurgy.	RF-P085, ID-P091
Potassium chromate	RFO	trace	Liquid waste would be processed in B774, 742 sludge or to solar evaporation ponds.	In B779, used in unknown process.	RF-P085, ID-P091
Potassium fluoride	RFO	trace	Liquid waste would be processed in B774, 741 sludge.	In B771, used in unknown process.	RF-P091

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Potassium hydroxide	RFO	trace/minor	Consumed in the process. May be present in the combustible stream in small amounts. B771, all liquid wastes to B774, 741 sludge. B881, liquid wastes to B774, 742 sludge or to solar evaporation ponds.	In B771, used in the scrubbers, used in KOH precipitation in americium recovery process and in anion exchange. In B774, used to neutralize acids received (with sodium hydroxide). In B881, used in an unknown process, possibly in the lab.	RF-C211, RF-C227, RF-P091, RF-P260
Potassium iodate	RFO	trace	Consumed in the process. Most of the SS&C was processed to recover plutonium and neptunium. Possibly some present in the debris waste. Any liquid waste to B774, 741 sludge.	In B771, used in Pu and Np thermite reduction as part of the pyrotechnic initiators. In B771, potassium iodate is listed for use in an unnamed process (1971).	RF-C211, RF-P084, RF-P091, RF-P262
Potassium permanganate		trace	May be present in combustible stream in small amounts. B122 liquid waste sent to the solar evaporation ponds. B123 liquid waste to B774, 742 sludge, or to solar evaporation ponds.	B122, used for personnel decontamination. B123, used as a laboratory reagent.	RF-P085, RF-P181
Purifloc®	RFO	trace	Replaced Seperan® in B774. Consumed in the process. Will be in both 741 and 742 sludges.	Used as a flocculating agent in radioactive decontamination in B774, 1st and 2nd Stage Precipitation.	RF-P047, RF-P260, RF-P265, RF-U115, RF-U136
Pyrene	ARA	trace	unknown	No use identified.	ARA-P010
Rhodium metal	RFO	trace	May be present in the debris stream in small amounts. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in the Coatings facility.	RF-P040
Selenium	ARA	trace	N/A	Found during environmental sampling. No indication that any will be in the waste.	ARA-P010, ARA-U001

Engineering Design File

Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Separan®	RFO	trace	Replaced by Purifloc® in 1964. Consumed in the process. May be in both 741 and 742 sludges.	Used as a flocculating agent in peroxide precipitation in B771. In B774 in radioactive decontamination, 1st and 2nd Stage Precipitation from 1953 to 1964.	RF-C096, RF-Cl32, RF-P068, RF-P098, RF-P108, RF-P165, RF-P262, RF-P265, RF-U048, RF-U110, RF-U111, RF-U283
Silicon carbide	ANL-W	trace	unknown	Used as an insulating powder at the FCF at EBR-II. No indication that this is included in the waste.	ANL-W-P001
Silicon dioxide, silicon monoxide	RFO	trace	May be present in the debris stream in small amounts. Liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in the Coating facility.	RF-P040
Silicone, Silicone oil	RFO	trace	Possibly present in the 74A/743 sludge. If in liquid stream; to B774, 742 sludge, or to the solar evaporation ponds.	B444, use unknown. B779, use unknown.	RF-C215
Silver metal, silver salts, silver nitrate, silver sulfate, silver oxide	PER-601-1H: Combustibles (paper, etc.)	trace	Possibly present in combustible waste in small amounts. B441 and B444 liquid waste processed in B774, 742 sludge, or sent to the solar evaporation ponds. B771 liquid waste processed in B774, 741 sludge, or the solar evaporation ponds. B776/777 and B779 liquid waste processed in B774, 742 sludge. Silver solder may be present in the combustible or noncombustible streams in small amounts. Unknown for INEEL	In B441, used in NDT analysis and film processing. In B444 and B771, used in parts coating, plating, and nondestructive testing. In B444, used in physical metallurgy. In B771, B776/777, and B779, R&D operations performed silver plating and coating.	RF-P084, RF-P091, ARA-P002-7, ARA-P009, ID-P091

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Soda lime, (mixture of calcium oxide and sodium or potassium hydroxide)	RFO	trace	Consumed in the process. Liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in chemistry technology.	RF-P040
Sodium salt of p-(2,4- dihydroxyphenylazo) benzenesulfonic acid.	RFO	trace	B771 liquid waste to B774, 741 sludge. May have been bottled and processed in 744 sludge.	In B771, no use was identified.	RF-P084
Sodium acetate	RFO	trace	B771 liquid waste to B774, 741 sludge. May have been bottled and processed in 744 sludge.	In B771, listed on an inventory, use unknown.	RF-P091
Sodium bicarbonate, baking soda	RFO	trace	B881 and B991 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. May have been bottled and processed in 744 sludge.	B881, listed on an inventory, use unknown. B991, listed on an inventory, use unknown.	RF-C227
Sodium, sodium-potassium, NaK	TAN-633-4H: Samples and specimens from examination of ML-1, PM-2A, and SNAPTRAN systems CPP ANL-W	trace	unknown	ANL-W used in reactor cooling. CPP processed waste.	ANL-W-P001, ANL- W-P009, ARA-P008, ID-P091
Sodium carbonate	RFO	trace	Possibly present in the combustible stream in small amounts. B444 and B447 liquid wastes processed in B774, 742 sludge, or to the solar evaporation ponds. B883 eutectic salts, when no longer useful, were drummed in B883 and sent to RWMG.	A component of Oakite, used as a solvent in B444. In B447, used in chemical milling of depleted uranium, beryllium, tungsten, brass, aluminum, and copper. In B444, B881 and B883, a component at eutectic baths used prior to rolling uranium (depleted and enriched).	RF-C227, RF-P084, RF-P091
Sodium chloride	RFO-DOW-17H: Evaporator salts RFO	trace	May be present in the combustible stream in small amounts. B447, liquid waste processed in B774, 742 sludge, or to the solar evaporation ponds.	In B447, used in chemical milling of depleted uranium, beryllium, tungsten, brass, aluminum, and copper.	ARA-P008

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Sodium dichromate RFO	RFO-DOW-17H: Evaporator salts RFO	trace	Possibly present in the combustible stream in small amounts. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in chemistry technology.	RF-P085, RF-P091, ID-P091
Sodium fluoride RFO		trace	Consumed in the process.	In B771, used in the fluidized bed fluorinator in lab-scale, pilot-scale, and production-scale operations.	RF-C044, RF-P108, RF-U172
Sodium hydroxide RFO	CFA-684-1H: Irradiated steel specimens, rags, paper, plastic bags, and some graphite	trace	Consumed in the process, may be present in combustible stream in small amounts. B123, B444, B779, and B881 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	In B123, used in the HP lab. In B444, component of Oakite, used as a solvent. In B771, used in solvent extraction and peroxide precipitation. In B774, used to neutralize acids (with potassium hydroxide). In B779, used in the Coatings facility. In B881, used in analytical processes. Used at non-RFP sites to regenerate ion exchange resins. unknown at INEEL	RF-C227, RF-P040, RF-P068, RF-P084, RF-P085, RF-P091, RF-P108, RF-P181, RF-P260, ANL-W-P009, ARA-P008, ARA-U003
Sodium hypochloride RFO		trace	Liquid waste to B774, 741 sludge.	In B771, no use identified.	RF-P091
Sodium methyl cellulose RFO		trace	May be present in graphite stream in small amounts. Liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444, used in uranium casting as a graphite mold and crucible coating.	RF-P084
Sodium nitrate CPP-601-4H: Acidic aqueous liquid RFO-DOW-17H: Evaporator salts RFO		trace	May be present in the combustible stream in small amounts. B447 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B447, used in chemical milling of depleted uranium, beryllium, tungsten, brass, aluminum, and copper.	ID-U297
Sodium nitride RFO		trace	B771 liquid waste to B774, 741 sludge.	In B771, no use identified.	RF-P091
Sodium nitrite RFO		trace	B771 liquid waste to B774, 741 sludge.	In B771, use not identified.	RF-P262, ID-P091
Sodium peroxide RFO		trace	Consumed in the process. Any sodium peroxide would be in sand, slag, and crucible – little of this was sent to INEEL, most went to dissolution for recovery.	In B771, used in Pu and Np thermite reduction as part of the pyrotechnic initiators.	RF-C211, RF-P084, RF-P091, RF-P262

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Sodium phosphate ANL-W	RFO-DOW-17H: Evaporator salts ANL-W	trace	unknown	ANL-W – No use identified.	ARA-P008, ID-P091
Sodium sulfate ANL-W	RFO-DOW-17H: Evaporator salts ANL-W	trace	unknown	ANL-W – No use identified.	ARA-P009, ID-P091
Sodium sulfite RFO	ANL-W RFO	trace	B771 liquid waste to B774, 741 sludge. ANL-W - unknown	In B771 – no use identified. ANL-W – No use identified.	RF-P091, ARA-P008
Sodium thiosulfate	RFO	trace	May be in combustible stream in small amounts. B883 liquid waste to B774, 742 sludge, or solar evaporation ponds.	In B883, component of Developer Rack Cleaner.	RF-C215
Sulfamic acid RFO	RFO	trace	Consumed in the process, may be in combustible stream in small amounts. B771 liquid waste to B774, 741 sludge.	In B771, used in the dissolution process to add sulfate to process.	RF-C211, RF-P068, RF-P091
Sulfur hexafluoride RFO	RFO	trace	B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444, used for an unknown purpose.	RF-P085
Sulfuric acid CPP-601-4H: Acidic aqueous liquid RFO	CFA-640-1H: Machine shop waste (metal chips and cleanup materials), batteries, and a cabinet from SL-1. Some stainless and lead, batteries contained acid CPP-601-4H: Acidic aqueous liquid RFO	trace	B444, B779, and B881 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	In B444, used in physical metallurgy and in the plating process. In B881, used in Oralloy leach (until 1973). In B771, used in Part V leach, peroxide precipitation (with nitric acid), and neptunium dissolution. In B779, used in Nuclear Joining and for coatings, brazing, and metallurgy.	RF-C211, RF-P040, RF-P068, RF-P084, RF-P085, ARA-P002-8

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Tantalum metal	RFO	trace	Present in the debris stream. B771 liquid waste to B774, 741 sludge. B776/777, B779, B881 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds.	In B881, used in special order work. In B776/777, waste generated from molten salt extraction (crucibles, stirrers, electrodes) and in the plutonium foundry and recovery operations (B771). In B779, used in the Coatings facility and in R&D operations.	RF-P040, RF-P047, RF-P064, RF-P084
Tartaric acid	RFO	trace	B771 liquid waste to B774, 741 sludge.	In B771, no use identified.	RF-P091
Terphenyl (Santo wax)	ANL-W TRA-603-23H: Terphenyl (Santo wax)	trace	unknown	At ANL-W, used in scintillation counting.	ID-P091
Tetrabromoethylene	RFO	trace	B444 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	B444, float sink separation process media in conjunction with Be work.	RF-P085
Tetrachloroethylene, Perchloroethylene, PCE	RFO-DOW-15H: Organic sludge	minor	Waste coolant drummed and sent to 903 Pad for storage. 903 Pad waste solutions sent to B774, 74A/743 sludge. Waste coolant generated after 1966 sent/pumped to B774, 74A/743 sludge. B559 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	B441, B444, B776/777, B779, B881, B883, B886, and B991; used as a cleaning and degreasing solvent. B444 used to reconditioning coolant lines. In B559, used in laboratory operations. B779 use unknown.	RF-C195, RF-C215, RF-C406, RF-P084, RF-P085, RF-U115, RF-U188
Thorium	ANL-W	trace	unknown	At ANL-W, used as a mold and crucible coating for metal refining at FCF. No indication that this was included in the waste to RWMC.	ANL-W-P001, ANL-W-P002
Thorium metal	RFO	trace	May be present in the debris stream. B779 liquid waste to B774	In B779, used in Nuclear joining.	RF-P040

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Tin metal	RFO	trace	May be present in the debris stream.	In B779, used in R&D operations.	RF-P040
Titanium metal	RFO	trace	May be in the noncombustible stream in small amounts. B444/447, B779 liquid wastes to B774, 742 sludge, or to the solar evaporation ponds.	In B444, used in parts casting and alloying. In B447, used in physical metallurgy. In B779, used in Nuclear Joining.	RF-P040, RF-P047, RF-P085
Toluene	PER-ORM-1H: Paper, cloth, wood, Santo wax, and empty barrels RFO	trace	May have evaporated, possibly in the combustible stream in small amounts. B123 liquid waste to B774, 742 sludge, or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge. May have been bottled and processed to 744 sludge.	In B123, used in the HP lab. In B771, used by HP radiation technicians to remove rubber cement from film frames. Common constituent in paint, stripper, and thinner.	RF-C406, RF-P181, RF-U182, ARA-P009, ARA-P010
Tributyl phosphate	CPP-601-5H: Organic solvents RFO	trace	May be present in the combustible stream in small amounts. B771 liquid waste containing traces of this product to B774, 741 sludge. CPP unknown	In B771, used by Special Recovery in uranium solvent extraction. At CPP, used in solvent extraction process for enriched uranium.	RF-P091, RF-P262, ANL-W-P009, ID-P091
Trichloroethylene, TCE, Alk-Tri, Neu-Tri,	PER-601-1H: Combustibles (paper, etc.) PER-ORM-1H: Paper, cloth, wood, Santo wax, and empty barrels RFO-DOW-15H: Organic sludge	trace/minor	May be present in the combustible stream in small amounts. Waste TCE drummed and sent to 903 Pad for storage. 903 Pad waste solutions sent to B774, 74A/743 sludge. Waste TCE generated after 1966 sent/pumped to B774, 74A/743 sludge. Some may have gone to B774, 741 and 742 sludge, in small amount.	In B441, used as a solvent. In B444, used in Process Chemistry R&D. In B447, used in Metallurgical Operations. In B771, used in Plutonium Fabrication R&D. In B777, used in Assembly Operations and Special Assembly Operations. In B779 used in R&D. In B881, used in Metallurgical Operations, Assembly Operations, and Fabrication Operations. In B883, used in Metallurgical operations. In B991 used in final assembly.	RF-C196, RF-C211, RF-C214, RF-C215, RF-C227, RF-C406, RF-P084, RF-P085, RF-P241, RF-U115, ANL-W-P001, ARA-P009, ID-P091

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Trichloro-fluoromethane	ARA	trace N/A		Found in environmental sampling performed at ARA. There is no indication that this was in any waste sent to RWMC.	ARA-P010
Trimethylolpropane-triester	TAN-633-4H: Samples and specimens from examination of ML-1, PM-2A, and SNAPTRAN systems No RFO waste streams associated with trimethylolpropane-triester in any year	trace	None	Trimethylolpropane-triester reported in 1966 only. TAN shipments to pit four area of interest consist of general plant waste and equipment.	RF-C409
Trisodium phosphate	NRF PER	trace	unknown	At NRF and PER, detergent used to clean reactor vessel surfaces.	ARA-P008, PER-P006
Tungsten metal	RFO	trace	May be present in the debris stream. B444 and B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444, used in manufacturing. In B779, used in welding in Nuclear Joining.	RF-P040, RF-P085
Uranyl nitrate	CPP-601-4H: Acidic aqueous liquid RFO	trace	May be in the combustible stream in small amounts.	In B886 uranyl nitrate was used in criticality experiments.	RF-P085
Vanadium metal	RFO	trace	May be present in the debris stream in small amounts. B444 and B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B444, used in Physical Metallurgy. In B779, used in the Coatings facility.	RF-P040, RF-P085
Vermiculite	ANL-W	trace	unknown	At ANL-W, used to absorb liquid wastes in 30-gallon drums. There is no indication as to the volume used or the number of drums.	ANL-W-P001
VascoMax® (C- series: Al, C, Co, Mn, Mo alloy; T- series: Al, C, Mn, Mo, Ni alloy)	RFO	trace	May be present in the debris stream.	In B779, used in the Coatings facility as a substrate.	RF-P040

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Xenon trioxide	RFO-DOW-3H: Uncemented Sludge	trace	Consumed in the process. B779 liquid waste to B774, 742 sludge, or to the solar evaporation ponds.	In B779, used in chemistry technology in a study of the reaction of plutonium with xenon trioxide in a perchlorate medium in 1966.	RF-U208
Xylene	PER-ORM-1H: Paper, cloth, wood, Santo wax, and empty barrels RFO-DOW-3H: Uncemented Sludge RFO-DOW-	trace	May be in combustible stream in small amounts. B123, B559, B881 liquid waste to B774, 742 sludge or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge. Lab wastes were also bottled and processed in B774, 744 sludge.	Used in B123, B559, B771, B881 laboratories.	RF-C215, RF-C406, ARA-P008, ARA-P009, ARA-P010, ID-P091
Yttrium metal, yttrium oxide	RFO	trace	May be in the graphite and the debris streams. B444 and B779 liquid wastes to B774, 742 sludge or to the solar evaporation ponds. B771 liquid waste to B774, 741 sludge.	In B444, used to coat beryllium and uranium graphite molds prior to use. In B771, used to coat plutonium graphite molds prior to use. In B779, used in the Coatings facility.	RF-P040, RF-P084, RF-P091
Zinc metal	RFO	trace	May be present in the debris stream.	In B779, used in R&D operations.	RF-P040
Zirconia, Zirconium oxide	ANL-W CFA CPP NRF PER	trace	unknown	At ANL-W, used to coat metal refining crucibles and molds. There is no indication that this was in the waste sent to the RWMC. At ANL-W, CFA, NRF, PER, used in ternary fuel. There is no indication that reactor fuel was sent to the RWMC. CPP processed ternary fuel elements.	RF-P047, ANL-W-P001, ANL-W-P002, ID-P091

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Table 4. (continued).

Combined Chemical Constituents List	Waste Streams 1963 – 1967	Amount in Waste	Which Wastes?	Wastren Comments	AK Reference
Zirconium, zirconium alloys	ANL-W CPP-601-7H NRF-618-5H: Zirconium alloy scrap PER	trace unknown		At ANL-W, NRF, PER, used as reactor fuel cladding material. There is no indication that solid zirconium cladding or zirconium alloy (zircaloy) was sent to the RWMC.	RF-P047, ANL-W-P001, ANL-W-P002, ID-P091

ANL = Argonne National Laboratory

ANL-W = Argonne National Laboratory-West

ARA = Auxiliary Reactor Area

CFA = Central Facilities Area

CPP = Chemical Processing Plant

DOW = Dow Chemical

HDT = Historical Data Task

ID = Idaho

INEL = Idaho National Engineering Laboratory

INTEC = Idaho Nuclear Technology and Engineering Center

NRF = Naval Reactors Facility

PER = Power Excursion Reactor

RF = Rocky Flats

RFO = Rocky Flats Operation

RWMC = Radioactive Waste Management Complex

TAN = Test Area North

TRA = Test Reactor Area

A major source of data concerning waste and contaminants disposed in the designated area of Pit 4 are the waste shipment documents. Each shipment document includes a specific disposal location that enables the identification of what shipments were disposed in the designated area of Pit 4. Shipment data indicates that waste disposed in the designated area originated from both onsite sources and the RFP. A listing of the shipments that were disposed in the designated area of Pit 4 can be found in Table B-1 in Appendix B.

An additional source of data considered was the Historical Data Task (HDT) (INEL-95/0310). The HDT is a comprehensive inventory of radiological and nonradiological contaminants buried in the SDA. The inventory data in HDT is organized by waste stream, generally a collection of waste with similar content, and is not linked to individual shipments. Hence the HDT data does not provide data as to where the identified constituents were disposed. A major difficulty in identifying chemical constituents buried in the designated area of Pit 4 was that shipment document data that listed disposal location lacked data describing shipment composition. Hence, it has been necessary to correlate chemical compounds used and potentially disposed as waste with the shipments identified as being disposed in Pit 4. This section identifies the generators of the waste that has been disposed in the designated area of Pit 4 and lists all potentially hazardous chemicals that may have been disposed in the designated area of Pit 4.

3. CHEMICAL COMPATIBILITIES

3.1 Purpose

This section presents an evaluation of the potential for incompatible chemical reactions in the waste inventory of the designated retrieval area in Pit 4 that will be retrieved as part of the ARP. This evaluation considered the range of possible chemical combinations (i.e., binary combinations) that could occur during excavation, repackaging, and storage. The potential adverse chemical reactions (e.g., generation of fire, explosion, heat, or fumes) that stem from combining chemicals at ambient temperatures also were considered. This evaluation will support the ARP characterization, and operational decision-making process by identifying chemical combinations that may potentially lead to adverse chemical reactions and affect project compliance and safety. A map showing the location of the RWMC at the INEEL is presented in Figure 1 followed by a map of the SDA showing the location of the designated retrieval area of Pit 4, provided in Figure 2.

3.2 Summary of Existing Technical Documentation and Evaluation Process

This section provides the technical documentation on which the chemical compatibility evaluation is based. The evaluation follows the methodology for assessing chemical compatibility as presented in the EPA document *A Method for Determining the Compatibility of Hazardous Wastes* (EPA 1980). Consistent with the EPA guidance, the evaluation performed in this EDF evaluates the potential range of all binary combinations of chemicals in the ARP waste inventory.

Several previous assessments of chemical compatibility have been performed on SDA waste streams similar to that in Pit 4 as part of Pit 9 remediation activities. The evaluations from the report, *Evaluation of Chemical Compatibilities of the OU 7-10 Glovebox Excavator Method Project* (Dick and Burton 2002) are utilized extensively in the analysis presented below, and are extensively quoted, with modifications as required, without further attribution.

A refined chemical compatibility evaluation of contaminants was performed and documented in *Evaluation of Chemical Compatibilities of the OU 7-10 Glovebox Excavator Method Project*, (INEEL/EXT-01-01587). A compatibility study including ternary combinations was considered and then rejected because, as stated in *A Method for Determining the Compatibility of Hazardous Wastes* (EPA 1980), it would be unwieldy. Furthermore, the mixtures considered in this analysis would involve solid-state reactions at ambient temperatures and pressures. The formation of a three-membered transition state in solids would be infrequent at best; therefore, reactions requiring three reactants to come together in a reactive intermediate would not be rapid. The possibility of sequential reactions involving three reactants also was considered and similarly evaluated. However, if a metal fire were to significantly heat the reactants, then a different outcome would be possible..

Key definitions are provided below to enhance understanding of the chemical compatibility evaluation. The first three definitions were derived from DOE Manual 440.1-1, “DOE Explosives Safety Manual.”

- **Explosive:** Any chemical compound or mechanical mixture that, when subjected to heat, impact, friction, shock, or other suitable initiation stimulus, undergoes a very rapid chemical change with the evolution of large volumes of highly heated gases that exert pressures in the surrounding medium. The term applies to materials that either detonate or deflagrate. The DOE explosives may be dyed various colors, except pink, which is reserved for mock explosives.
- **Deflagration:** A rapid chemical reaction in which the output of heat is sufficient to enable the reaction to proceed and be accelerated without input of heat from another source. Deflagration is a surface phenomenon with the reaction products flowing away from the unreacted material along the surface at subsonic velocity. The effect of a true deflagration under confinement is an explosion. Confinement of the reaction increases pressure, rate of reaction, and temperature, and may cause transition into a detonation.
- **Detonation:** A violent chemical reaction within a chemical compound or mechanical mixture involving heat and pressure. A detonation is a reaction that proceeds through the reacted material toward the unreacted material at a supersonic velocity. The result of the chemical reaction is exertion of extremely high pressure on the surrounding medium, forming a propagating shock wave that is originally of supersonic velocity. When the material is located on or near the surface of the ground, a detonation is normally characterized by a crater.

In the present work, incompatible is defined by both 40 CFR 264.17(b) and EPA (1980). The definition from 40 CFR 264.17(b) for this evaluation is provided below.

- **Incompatible:** “A mixture of chemicals that can lead to the effects described in 40 CFR 264.17(b), and EPA 1980. Thus, compatible chemicals may react slowly over time, and even generate heat, but will not lead to disastrous effects such as (1) Generate extreme heat or pressure, fire or explosions, or violent reactions, (2) Produce uncontrolled toxic mists, fumes, dusts, or gases in sufficient quantities to threaten human health or the environment; (3) Produce uncontrolled flammable fumes or gases in sufficient quantities to pose a risk of fire or explosions; (4) Damage the structural integrity of the device or facility; (5) Through other like means threaten human health or the environment.” Note the use of the terms extreme and uncontrolled, and specification of damage to the structural integrity of the facility.

The issues as discussed in EPA (1980, Section 1, p. 1) are quoted below:

The ‘combination of solid wastes’ part of the definition often presents problems in many aspects of the management of hazardous waste. In some instances, the combination or mixture of two or more types of the waste produces undesirable or uncontrolled reactions resulting in adverse consequences. These reactions may cause any one or more of the following: (1) heat generation, (2) fire, (3) explosion, (4) formation of toxic fumes, (5) formation of flammable gases, (6) volatilization of toxic or flammable substances, (7) formation of substances of greater toxicity, (8) formation of shock and friction sensitive compounds, (9) pressurization in closed vessels, (10) solubilization of toxic substances, (11) dispersal of toxic dusts, mists, and particles, and (12) violent polymerization. In this report, such reactions are called **incompatible reactions** and the reacting waste is called **incompatible wastes** (emphasis added). Again note the use of the terms uncontrolled reactions and adverse consequences.

In this analysis, incompatible types of waste are to be considered as chemicals that will react to produce heat sufficient to cause a runaway reaction during storage, a fire or explosion, or the liberation of toxic gases at a rate sufficient to constitute a threat to human health or the environment. Insufficient test data exist to preclude all possibility of reactions with long induction periods. It is recognized that some reactions may proceed at ambient temperatures at a rate sufficient to produce some heat and toxic gases, but not at a rate to present a hazard to human health or the environment.

3.2.1 Chemical Compatibility Evaluation

Based on the inventory evaluation table presented in Section 2, (Table 4, WASTREN Table), the majority of chemicals are present in the waste in limited concentrations that are characterized as “trace” in the table. The chemicals that are identified as trace quantities in Table 4 above, are not evaluated further for compatibility as it is concluded that there is not sufficient material present to lead to incompatible reactions. Chemicals likely to be present in the waste in minor or major quantities and concentrations based on the AK report also present no compatibility hazards, and are discussed below.

The limiting of the compatibility evaluation to the chemicals discussed below is predicated on the assumed accuracy of the Wastren Table presented above, which is based in part on the AK report previously referenced. The actual presence of chemicals in concentrations greater than “trace” as reported in the Wastren Table could possibly result in adverse consequences due to unanticipated reactions.

Beryllium — Alcohols (Butyl and Methyl): Beryllium reacts with alcohols to form alkoxides, but the alcohols are not present in sufficient concentration within Pit 4 for a reaction to occur, and beryllium is present only in trace amounts.

Cadmium metal — Air: Finely divided metal is pyrophoric, but is unlikely to be present other than cemented in the waste.

Calcium chloride: No compatibility hazard.

Calcium fluoride: No compatibility hazard.

Calcium silicate: No compatibility hazard.

Carbon tetrachloride: Not reactive with other chemicals present; hence no compatibility hazard.

Sodium Cyanide — acids: May be present as discarded contaminated excess chemical, possibly in 25-pound quantities. Recommend separation if found packaged in waste; otherwise high water solubility (480 grams/liter at 10°C) will have resulted in dispersal throughout waste.

Ferric sulfate: No compatibility hazard.

Freon: No compatibility hazard.

Lead metal: May be present, but relatively unreactive and presents no compatibility hazard.

Mercury metal: May be present as discarded contaminated excess chemical, but presents no compatibility hazard.

Metal turnings, shavings, powders — Air: While expected to be found cemented in the waste, and hence oxidized, any bags or other containers, if found, should be considered potentially pyrophoric and separated and handled accordingly.

Methanol: Only in trace to minor concentrations, presenting no compatibility hazards.

Nitric acid — Oils, cellulose (rags and paper), and other organics: Strong oxidizing agent, but should only be present in low concentrations due to high water solubility, and neutralization prior to and during cementation of waste. Not in high enough concentration for nitration of cellulose in rags or paper to nitrocellulose.

Plutonium and Plutonium Oxide — Air: Unoxidized plutonium metal could still exist in Area 1 of Pit 4.^b An oxide coating would be expected to be covering the plutonium metal; however, disruption of the coating could lead to a smoldering plutonium fire if a mixture of plutonium oxide and plutonium hydride were present on the surface and ignited. Plutonium forms sesquioxides (Pu_2O_3) as well as the most stable dioxide (PuO_2) (DOE-HDBK-1081-94; DOE 1994). Therefore, depending on the conditions, even though all plutonium may have oxidized, a pyrophoric coating of oxides and hydrides could have formed in the presence of air and moisture. These could ignite on exposure to air.

Portland cement: No compatibility hazard.

Tetrachloroethylene (PCE): Not reactive with other chemicals present; hence, no compatibility hazard.

1,1,1-Trichloroethane (TCA): Not reactive with other chemicals present; hence, no compatibility hazard.

Trichloroethylene (TCE): Not reactive with other chemicals present; hence, no compatibility hazard.

Uranium and Uranium Oxide — Air: Unoxidized uranium could still exist in Area 1 of Pit 4 (see footnote a). An oxide coating would be expected to be covering the uranium metal; however, disruption of the coating could lead to a uranium fire if a mixture of uranium oxide and uranium hydride were present on the surface and ignited. Uranium forms sesquioxides (UO_2 and U_2O_5) as

b. John R. Dick Personal Conversation with James D. Navratil, July 1999, "Existence of Plutonium Metal in Pit 9," Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.

well as the more stable trioxide (UO_3). Therefore, depending on the conditions, even though all uranium may have oxidized, a pyrophoric coating of oxides and hydrides could have formed in the presence of air and moisture. These could ignite when exposed to air as could any unoxidized uranium metal. The roasting process was intended to convert all metal to U_3O_8 , but chunks of uranium metal have been found in drums of roaster oxide.

Anecdotal and 1960's logbooks evidence strongly suggests^c the possibility of finding discarded radioactively contaminated excess chemicals in the waste. Any bottles found in the sludges should be treated with appropriate caution, as they may contain any chemicals used in the RFP production or laboratory areas during that time period. The possibility of peroxide-forming, or otherwise unstable, chemicals cannot be excluded. While dilute when used to stabilize 1,1,1-trichloroethane, 1,4-dioxane if present neat in bottles could form explosive peroxides. Other chemicals of concern that could contain peroxides if discarded in pure form in the waste include dibutyl carbitol, hexone, 2-butanone, and methylisobutyl ketone. Picric acid (2,4,6-trinitrophenol) was used in the RFP production facilities during the time in question. Hydroxylamine and hydroxylamine nitrate are also very energetic, and were also listed in the inventory. Any unidentifiable bottles found should be handled appropriately as potentially explosive. Operations planning documented in the project Safety Analysis Report and *Removal Action Plan for the Accelerated Retrieval Project for a Described Area within Pit 4*, (DOE-ID-11178) indicates that identification of containerized chemicals that have not been addressed in operating procedures will require waste handling operations to be stopped. The bottles will be subjected to the unreviewed safety question (USQ) process from which appropriate operational steps will be developed for managing the chemicals in a safe manner under an approved recovery plan. The containers in question will be separated from the repackaged targeted waste stream as the items would generally be prohibited from disposal at the Waste Isolation Pilot Plant. INEEL management control procedures (MCPs) that address management of unknowns may be followed for storage of any such chemicals that are removed from the drum packaging stations. Unknown chemicals would require storage as if incompatible with other wastes or materials (i.e., separation by distance/barrier will be required to store unknowns).

4. CONCLUSIONS

An examination of inventory records and AK documentation and consideration of possible binary combinations of wastes due to incidental mixing during retrieval operations reveals no incompatible combinations of waste, providing the repackaged waste is stored at ambient temperatures. The possibility of encountering unknown discarded chemicals in the waste cannot be excluded. Any unidentifiable bottles found in the waste should be treated with appropriate caution by expert personnel.

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Appendix A

Potassium and Sodium Nitrate

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Appendix A

Potassium and Sodium Nitrate

A-1. POTASSIUM AND SODIUM NITRATE — METALS

It is assumed for the purpose of this evaluation that drums of 745 sludge containing sodium and potassium nitrate are not present in Area 1 of Pit 4; nevertheless an evaluation of the possible consequences if unexpected 745 sludge is unearthed is presented in this section for completeness.

The metals identified as presenting potential compatibility concerns with 745 Sludge include beryllium, cadmium, chromium, lead, mercury, silver, and zirconium. In addition, plutonium, uranium, and calcium also are present. In the absence of heat, bulk metal will not react with sodium or potassium nitrate during packaging or storage. Powdered and finely divided metals are the basis of pyrotechnics and can react readily with potassium or sodium nitrate. Powdered or very finely divided cadmium, chromium, or zirconium should be mostly oxidized and no longer pyrophoric, but could be protected by a protective oxide coating which, if physically disrupted, might expose fresh metal surfaces. Calcium metal may be present but would not react with sodium or potassium nitrate because the latter alkali metals have a higher oxidation potential than calcium. Cadmium and chromium are known to react with fused ammonium nitrate below 200°C (392°F) (Bretherick 1991). While expected to be found cemented in the waste, and hence oxidized, any bags or other containers, if found, should be considered potentially pyrophoric and incompatible with 745 Sludge and separated and handled accordingly.

The safety analysis for this project anticipates metal fires and project operations are prepared to suppress them.

A-2. POTASSIUM AND SODIUM NITRATE — OILS

A series of tests was performed at the Energetic Materials Research and Testing Center at the New Mexico Institute of Mining and Technology (commonly known as New Mexico Tech) in Socorro, New Mexico, to determine the reactions of nitrate salts with potential fuels when heated (Dick 2001). The greatest concern was the possibility of an explosive reaction between the nitrate salts present in the SDA in the form of Series 745 sludge and the large amount of oils present as Series 743 sludge. These are mainly Texaco Regal R&O or Shell Vitrea machining oils, cut with chlorinated solvents such as carbon tetrachloride, tetrachloroethene, trichloroethene, and 1,1,1-trichloroethane. The oils were packaged with calcium silicate to form a solid sludge at the RFP, but after many years in the SDA they may have separated because of decomposition, displacement by water, sedimentation, evaporation, or condensation.

Oils becoming mobile when heated, running into ruptured nitrate drums, and exploding during in situ vitrification constituted one scenario of concern. Nitrates melting and flowing into oil drums, and again possibly exploding when heated, constituted another scenario. Furthermore, the carbon tetrachloride, postulated to reduce the reactivity of the oils, may well have evaporated from the oil and migrated, as evidenced by the large amounts of carbon tetrachloride removed from the SDA by organic contamination in the vadose zone extraction methodology, and consequently not be available as a fire suppressant.

The Independent Technical Review Panel (ITRP) performed preliminary tests to determine the explosive properties of nitrate salts when mixed with fuels (ITRP 1999). Mixtures of nitrates and 10%

Regal Oil were tested for impact, static, and friction, without any initiations. A 1-gal mixture, when boosted with 150 g (5.3 oz) of Pentolite, did explode; however, the effects were estimated only by crater size. The Energetic Materials Research and Testing Center testers also were unable to cause explosions with mixtures of nitrates and oil.

Henkin and Koenen tests (Dick 2001) were conducted to determine critical explosion temperatures and violence of explosion under confinement. The Henkin and Koenen tests gave no explosions with the oil mixtures, even at the smallest orifice size in the Koenen test. The 5-gal container tests with oil, and with oil mixed with equal parts of carbon tetrachloride, only caught fire or smoked above 445°C (833°F). The drums were severely oxidized. The 55-gal drum test was heated for 1 week at 500°C (932°F) but did not explode. At 500°C (932°F) the oil distilled from the drum with decomposition. It may be possible to find a lower temperature at which the oil would not migrate but would eventually react fast enough with the decomposing nitrate salts to explode. The intimate interface of oil-soaked nitrate provides a possible reaction zone. The consequences of such an explosion could be severe because several hundred pounds could be involved with a nitrate drum into which oil has flowed. The mixture of oil and sodium or potassium nitrates is similar to ammonium nitrate fuel oil explosives; however, in the case of ammonium nitrate the compound can explode without any oil present. The diesel fuel sensitizes the ammonium nitrate and adds to the explosive energy, but is not necessary for an explosion. While not applicable to ambient temperature compatibility, attention is called to the potential hazard of any heat treatment of packaged drums.

In another test, the mixture of oil and nitrates did not ignite when the heaters arced and burned holes in the 5-gal drum. Burn rate tests were performed at the Energetic Materials Research and Testing Center to determine the flame propagation properties of nitrate salt mixtures. In the burn-rate tests, the nitrate and oil mixtures failed to ignite from a hot wire and propagate a flame front (Dick 2001).

During one blending of the oil with the nitrate test mixture in the drum tumbler, some of the mixture oozed from the mixing drum lid threads. The possibility of a chemical reaction was considered, but rejected because no heating or gas evolution was observed. The yellowing of the mixture was ascribed to traces of chromophores in the oil. After the mixtures were transported to the firing sites and poured into the 5- and 55-gal test containers, no heat or gas evolution was detected. During the heating at a rate of 100°C (212°F) increase per hour, evolution of CO, CO₂, NO, and NO₂ was observed, but no runaway reactions were experienced. No exothermicity was noted between 25 and 240°C (77 and 464°F), and mild exothermicity was noted in the radial thermocouple in the time versus temperature plots above 240°C (464°F).

At ambient temperatures, it is implausible that the nitrate salts if present will react with oils to produce either an explosion or a fire; therefore, they are not incompatible.

A-3. POTASSIUM AND SODIUM NITRATE — GRAPHITE

A nitrate mixture with 20-wt% graphite did not explode up to the maximum attainable temperature of 398°C (849°F) in the Henkin test. In the Koenen test, a 20-wt% graphite mixture resulted in a limiting diameter of 3 mm (0.1 in.), meaning the reaction fragmented the sample tubes. If the tests had been run for United Nations qualification of the material, the results would have been positive, meaning the material showed a violent effect on heating under confinement.

Graphite did not explode, but did burn on both the 5- and 55-gal scale when nitrate salts in an 80 to 20-wt% ratio were placed on top of the graphite and the drum was heated. The intense heat of the fires

melted the drums. In Test 19, where the graphite and nitrate salts were mixed 100 turns, the reaction was energetic and rapid enough to disrupt the surface of the ground.

After mixing, the graphite and nitrate test mixtures were transported to the firing site and poured into the 5- and 55-gal test containers. No heat or gas evolution was noted and no attempt was made to monitor gas evolution during heating. The plots of time versus temperature for Test 19 shown in Appendix B (p. B-22) and Test 26 (p. B-33) of Dick (2001) clearly show no exothermicity from 25 to 500°C (77 to 932°F).

The Henkin and Koenen tests for critical explosion temperature and violence under confinement represent the worst-case scenarios because the drums actually present in the SDA contain mostly graphite pieces and are unlikely to contain all fines or scarfs. Nitrates in contact with graphite, as is the case with oil, provide opportunities for large explosive quantities in one drum. It must be noted that sodium nitrate is deliquescent; it will absorb moisture from its surroundings until it dissolves in the absorbed moisture. Further discussions of sodium nitrate deliquescence can be found in the *Yucca Mountain Science and Engineering Report Technical Information Supporting Site Recommendation Consideration* (DOE 2001). Tables of relative aqueous-vapor pressures of various mixtures of solids, and of solids with their saturated solutions, are available from the work of N. Schoorl (Schoorl 1952; Kolthoff and Sandell 1952). Based on information from a draft memo from Michael J. Rohe,^d relative humidity in the vadose zone is close to 100%. Like gunpowder, nitrate mixtures will not burn rapidly or explode if wet. The ITRP concluded that explosions are beyond extremely unlikely if the moisture content is greater than 5 wt%, based on the failure to obtain an explosive yield even with a Pentolite booster when the moisture content was 5 wt% in the mixture with oil (ITRP 1999).

At ambient temperatures, it is implausible that nitrate salts will react with graphite to produce either an explosion or a fire; therefore, the mixture is not incompatible. Nevertheless, the mixture could be ignited by an ignition source.

A-4. POTASSIUM AND SODIUM NITRATE — HALOGENATED ORGANICS (CARBON TETRACHLORIDE, CHLOROFORM, METHYLENE CHLORIDE, TETRACHLOROETHENE, TRICHLOROETHENE, 1,1,1-TRICHLOROETHANE, AND FREON 113)

Nitrates will not react with halocarbons at ambient temperatures. A carbon tetrachloride and oil mixture smoked but did not take fire when heated to 500°C (932°F) with a mixture of sodium and potassium nitrate (Dick 2001). After mixing, the oil, carbon tetrachloride, and nitrate, test mixtures were transported to the firing site and poured into the 5- and 55-gal test containers. No heat or gas evolution was noted. A yellowing of the mixture was noted and ascribed to traces of chromophores. During the heating at a rate of 100°C (212°F) increase per hour, evolution of CO, CO₂, NO, and NO₂ was observed, but no runaway reactions were experienced.

According to the ITRP report, “Organic chloride solvents are all fire suppressants; therefore, the pure oil and nitrate mixture is clearly a bounding scenario” (ITRP 1999, p. 13). Thus, any mixture with perchlorated solvents should exhibit less reactivity than with the pure oil. Carbon tetrachloride has been employed as a fire extinguisher but has the disadvantage of forming phosgene at high temperatures.

^d Michael J. Rohe Personal Memorandum to George A. Beitel, “Relative Humidity in Vadose Zone Cavity (Draft),” January 18, 2002, Idaho National Engineering and Environmental laboratory, Bechtel BWXT Idaho, LLC, Idaho Falls, Idaho.

Nitrogen dioxide and dinitrogen tetraoxide undergo explosive reactions with unsaturated chlorocarbons such as tetrachloroethene and trichloroethene, but heating to well above 200°C (392°F) would be necessary to decompose the nitrates to yield NO₂. Under ambient storage conditions, nitrate salts will not react with the halocarbons listed above and the mixtures are not incompatible.

The possibility of phosgene generation was considered. Carbon tetrachloride will react with oxygen at elevated temperatures (such as in a fire) to form phosgene (COCl₂). A similar reaction of carbon tetrachloride with nitrates was considered; the reaction does not proceed at ambient temperatures. Phosgene is a nonpersistent war gas and rapidly reacts with moisture to form carbon dioxide and hydrogen chloride, which renders it not useful for attacks in rain or fog. It would react rapidly with moisture in the interstitial dirt or with water in the deluge system in the event of a fire.

A-5. POTASSIUM AND SODIUM NITRATE — RAGS

Nitrate salts can react with cellulose materials. Bretherick reported jute bags of nitrates catching fire on board a ship in the tropics (Bretherick 1991) and flash paper is made by impregnating paper with nitrate solutions. During the explosives tests in New Mexico, nitrate salts placed on top of dry rags and Kimwipes and heated above 300°C (572°F) underwent a temperature excursion that caused the lids and bottoms to bulge but showed no evidence of an explosion (Dick 2001). Nitrate-soaked rags and Kimwipes exploded in these tests and at lower temperatures than the nitrates on top of pyrolyzed rags. The explosive effects were less because only 30 kg (66 lb) of soaked and dried rags could be forced into a 55-gal drum. A drum was ignited with a hot wire and exploded at a temperature of only 150°C (302°F). Again, this was a worst-case and highly implausible scenario. The 65-wt% nitrate ratio was chosen as the highest nitrate concentration that could be achieved by the ITRP in its tests (ITRP 1999). During testing, this concentration could be achieved only by soaking the rags in a saturated nitrate solution at 60°C (140°F). The stoichiometric ratio for burning-to-CO₂ would be closer to 73% nitrates. It should be noted, however, that the 52% nitrate-soaked rags in Test 12d burned 25% faster than the 63% nitrate-soaked rags in Test 12c. Cheetah computer code (LLNL 1998) calculations indicate a rather broad range over which the nitrate-soaked rags can burn or deflagrate. It is not difficult to construct a scenario in which nitrate salts are dissolved from drums in the SDA and transported in solution to rag-filled drums. However, it would be difficult for the wet rags to dry to such a concentration of nitrates underground. It is implausible that any rags in the SDA would be dry; nevertheless, it would be prudent to separate them. If the packaged waste were to undergo subsequent heat treatment, then dried nitrate-soaked rags would be a concern.

After drying, the nitrate-soaked rags were transported to the firing site and placed into the 5- and 55-gal test containers. No heat or gas evolution was noted. During the heating at a rate of 100°C (212°F) increase per hour, evolution of CO, CO₂, NO, and NO₂ was observed.

Nitrate salt mixtures with cellulose did not pass the test for exclusion from the U.S. Department of Transportation Class 5, Division 5.1 oxidizer status when the salts were diluted with 20% soil or 25% water. The addition of 30% water did result in a pass.^e

Nitrate salts combined with rags or tissues would not result in a chemical incompatibility at ambient temperatures. If the packaged waste were to undergo subsequent heat treatment, then dried nitrate-soaked rags would present a reactivity concern.

e. Peter G. Shaw E-mail to James J. Jessmore, May 6, 1999 (forwarded E-mail from Vince Mendoza, Stresau Labs, to Reva Hyde, Idaho National Engineering and Environmental Laboratory), "Preliminary Test Results, INEEL Soil Sample Oxidizer Tests," Idaho National Engineering and Environmental Laboratory, Lockheed Martin Idaho Technologies Company, Idaho Falls, Idaho.

A-6. POTASSIUM AND SODIUM NITRATE — NITROBENZENE

Nitrates could react with nitrobenzene only in strong nitric acid with heating. The reaction to form meta-dinitrobenzene is endothermic and would not occur in the conditions currently existing in the SDA. Moreover, nitrobenzene is present, if at all, in trace quantities.

A-7. POTASSIUM AND SODIUM NITRATE — ORGANIC ACIDS, ALCOHOLS, ETHYLENEDIAMINETETRAACETIC ACID, ACETONE, AND XYLENE

In addressing the emplacement of Stage I probe holes, the ITRP concluded that reactions between nitrate salts and other organics is not a credible threat because they cannot come into contact in sufficient concentrations to produce an energetic event (ITRP 1999):

Second, for the concern that nitrates from 745-sludge may mix with organics in the 744-sludge, the alcohols, organic acids, and EDTA were mixed with Portland and magnesia cements, then covered with more Portland cement to form the 744-sludge (Ref. 14). In such a matrix, the organic acids would be tightly bound to the alkaline cement and the water-soluble alcohols would be solvated in the matrix like water. This would preclude their migration into nitrate sludge to form an explosive mixture. Third, although other organic compounds, such as butyl alcohol, xylenes, and acetone, are reported to be in Pit 9, the quantities are in parts per million and are of no concern because that level of concentration is insufficient to form a detonatable mixture with the nitrate sludge (Refs. 15 and 16).

No reactions have been hypothesized that could lead to explosion, rupture, or fumes even if the chemicals listed above were to become commingled; therefore, the mixtures are not incompatible.

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Appendix B

Waste Types by Disposal ID Number for the Waste Inventory Contained in the Described Area Including the Angle of Repose

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Appendix B

Waste Types by Disposal ID Number for the Waste Inventory Contained in the Described Area Including the Angle of Repose

Table B-1 provides a summary of waste types, by disposal ID number for the waste inventory contained in the described area including the angle of repose.

Table B-1. Summary of waste types by disposal ID number for the waste inventory contained in the described area including the angle of repose.

Waste Volumes by Type (ft ³)											
Disposal Footprint				Rocky Flats Plant Wastes							
Document ID Number (Sorted by ID)		Weight (lb)	Volume (ft ³)	X-axis (ft)	Y-axis (ft)	Width (ft)	Height (ft)	Scale Factor	Series 741 Sludge	Series 742 Sludge	Series 743 Sludge
ANL601SR012/20/66800 ^d	200	35	690.17	80.75	10	10	1	0	0	0	0
ANL767SR007/12/66150	3,000	34	752.83	0.50	10	10	1	0	0	0	0
ANL767SR010/13/66350	75	8	665.09	90.54	10	10	1	0	0	0	0
ARA602SR008/09/66110 ^e	1,200	252	624.94	109.21	10	10	1	0	0	0	0
ARA602SR008/10/66110	300	48	604.95	107.41	10	10	1	0	0	0	0
ARA602SR012/15/65830	20,000	1,200	634.01	69.04	13	13	1	0	0	0	0
ARA602SR012/17/65800	1,000	50	615.34	60.13	10	10	1	0	0	0	0
ARA602SR012/17/65810	1,000	50	605.26	70.05	10	10	1	0	0	0	0
ARA602SR012/17/65820	4,000	100	685.17	80.71	10	10	1	0	0	0	0
CFA601SR005/05/66100 ^f	1,000	100	600.22	75.00	10	10	1	0	0	0	0
CFA601SR005/06/66200	150	12	600.22	75.00	10	10	1	0	0	0	0
CFA601SR006/17/66131	6,000	656	609.98	103.79	10	10	1	0	0	0	0
CFA633SR005/06/66110	300	72	600.22	75.00	10	10	1	0	0	0	0
CFA633SR006/23/66200	80	4	609.94	108.94	10	10	1	0	0	0	0
CFA654SR011/23/66800	18,000	948	700.17	85.79	20	10	1	0	0	0	0
CFA687SR008/16/66110	1,000	9	614.94	108.62	10	10	1	0	0	0	0
CFA690SR005/04/66320	45	12	600.22	75.00	10	10	1	0	0	0	0
CPP601SR001/03/67800 ^g	500	80	705.17	80.87	10	10	1	0	0	0	0
CPP601SR001/05/67800	1,000	42	710.98	84.04	8	4	1	0	0	0	0
CPP601SR001/09/67800	800	40	740.21	76.16	10	10	1	0	0	0	0
CPP601SR001/23/67800	1,500	80	705.30	65.87	10	10	1	0	0	0	0
CPP601SR004/26/66230	2,000	108	594.96	106.51	10	10	1	0	0	0	0
CPP601SR005/06/66350	400	80	600.22	75.00	10	10	1	0	0	0	0
CPP601SR005/20/66110	1,000	220	704.96	106.49	10	10	1	0	0	0	0
CPP601SR005/24/66251	1,500	100	594.95	106.60	10	10	1	0	0	0	0
CPP601SR006/15/66100	1,000	100	614.95	106.76	10	10	1	0	0	0	0
CPP601SR006/15/66200	1,000	100	614.95	106.76	10	10	1	0	0	0	0
CPP601SR006/16/66151	1,000	100	614.95	106.76	10	10	1	0	0	0	0
CPP601SR007/27/66210	500	54	649.95	107.67	10	10	1	0	0	0	0
CPP601SR007/28/66210	300	54	649.95	107.67	10	10	1	0	0	0	0
CPP601SR008/09/66151	300	84	589.95	106.74	10	10	1	0	0	0	0
CPP601SR008/15/66110	4,000	48	604.95	107.41	10	10	1	0	0	0	0
CPP601SR008/15/66225	6,000	72	604.95	107.03	10	10	1	0	0	0	0
CPP601SR008/18/66150	1,500	81	639.95	107.19	10	10	1	0	0	0	0
CPP601SR008/25/66130	3,000	108	734.96	107.66	10	10	1	0	0	0	0
CPP601SR010/07/66120	3,000	108	719.96	107.54	10	10	1	0	0	0	0
CPP601SR010/07/66120	1,000	100	640.05	95.33	10	10	1	0	0	0	0

Table B-1. (continued).

Table B-1. (continued).

Document ID Number (Sorted by ID)	Weight (lb)	Volume (ft ³)	Disposal Location ^a (upper left corner)			Disposal Footprint			Waste Volumes by Type (ft ³)													
			X-axis (ft)	Y-axis (ft)	Width (ft)	Height (ft)	Scale Factor	Series 741 Sludge	Series 742 Sludge	Series 743 Sludge	Series 744 Sludge	Line Generated Waste	Beryllium Contaminated Waste	Roaster Oxide (DUP ^b)	Graphite	Filters	Combustible Debris	Non- Combustible Debris	Sludge	Combustible Debris	Non- Combustible Debris	
Rocky Flats Plant Wastes																						
RFODOWSR102/03/6781020	27,432	1,110	700.54	40.79	20	15	1	0	0	0	0	7	66	74	0	0	449	507	7	0	0	
RFODOWSR102/10/6780020	26,955	1,111	720.46	50.95	15	20	1	0	0	0	0	44	95	0	0	0	574	398	0	0	0	
RFODOWSR102/10/6781010	35,369	558	720.54	40.96	15	15	1	169	118	169	44	7	0	0	0	0	29	22	0	0	0	
RFODOWSR102/10/6782020	36,404	1,095	730.63	31.03	15	20	1	316	7	0	0	15	0	0	0	0	529	228	0	0	0	
RFODOWSR102/10/6783030	36,266	1,120	730.46	51.03	15	20	1	265	66	96	15	0	0	0	0	0	328	350	0	0	0	
RFODOWSR102/17/6780020	27,794	1,727	730.46	51.03	40	15	1	0	0	0	0	0	110	74	0	0	1,168	103	272	0	0	
RFODOWSR102/17/67810150	31,255	558	730.54	41.04	40	15	1	272	103	7	59	0	0	0	0	0	66	51	0	0	0	
RFODOWSR102/17/6782020	35,879	1,132	730.63	31.03	40	15	1	0	37	287	125	0	0	0	0	0	110	573	0	0	0	
RFODOWSR102/17/6783000	32,300	2,213	785.38	61.49	35	15	1	0	0	0	0	0	0	0	0	0	1,098	0	1,115	0	0	
RFODOWSR102/24/6780020	35,910	1,118	740.62	31.12	30	40	1	221	66	118	88	0	0	0	0	0	33	592	0	0	0	
RFODOWSR102/24/6781090	34,996	1,120	740.62	31.12	30	40	1	162	74	15	74	29	0	0	0	0	486	280	0	0	0	
RFODOWSR103/03/6780020	32,325	1,125	750.71	21.21	35	15	1	0	0	0	0	0	22	154	0	0	0	448	501	0	0	0
RFODOWSR103/03/6781030	38,508	1,115	750.54	41.20	30	15	1	162	22	132	7	44	0	0	0	0	330	418	0	0	0	
RFODOWSR103/03/6782050	36,259	969	750.63	31.20	40	15	1	198	29	206	7	0	0	0	0	0	103	426	0	0	0	
RFODOWSR103/03/6783020	33,170	1,150	785.42	56.49	35	10	1	0	0	0	0	0	0	0	0	0	1,150	0	0	0	0	
RFODOWSR103/10/6780020	38,784	1,110	770.41	56.37	30	15	1	88	37	191	7	59	0	0	0	0	360	368	0	0	0	
RFODOWSR103/10/67810565	38,832	1,110	780.67	26.45	25	15	1	103	7	198	15	96	0	0	0	0	334	357	0	0	0	
RFODOWSR103/10/6782030	36,281	1,126	770.58	36.37	30	15	1	162	37	206	37	0	0	0	0	0	136	548	0	0	0	
RFODOWSR103/10/6783010	39,078	1,117	770.5	46.36	30	15	1	74	0	338	15	15	0	0	0	0	162	513	0	0	0	
RFODOWSR103/10/67810565	37,288	1,117	785.71	21.49	20	15	1	66	51	176	29	37	0	0	0	0	368	390	0	0	0	
RFODOWSR103/10/6782030	37,090	1,109	780.5	46.44	25	20	1	125	37	191	29	0	7	0	0	0	128	592	0	0	0	
RFODOWSR103/17/6782020	40,006	559	780.58	36.45	25	10	1	44	66	375	15	0	7	0	0	0	26	26	0	0	0	
RFODOWSR103/17/6783010	22,700	2,074	800.29	71.61	40	15	1	0	0	0	0	0	0	0	0	0	976	0	1,098	0	0	
RFODOWSR103/31/6780060	37,032	1,108	800.45	51.61	30	15	1	118	29	206	29	66	0	0	0	0	51	609	0	0	0	
RFODOWSR103/31/6781020	40,868	996	810.66	26.69	30	20	1	7	37	331	37	0	0	0	0	0	437	37	110	0	0	
RFODOWSR103/31/6782050	36,277	1,197	800.54	41.62	30	15	1	81	37	265	29	0	0	0	0	0	139	646	0	0	0	
RFODOWSR103/31/6783010	35,652	552	800.67	26.61	30	15	1	7	81	272	37	0	0	0	0	0	30	125	0	0	0	
RFODOWSR107/08/6681020	36,000	1,216	694.86	102.91	10	10	1	0	0	0	0	0	0	0	0	0	0	0	1,216	0	0	
RFODOWSR107/29/6682020	25,200	2,074	723.31	100.09	13	13	1	0	0	0	0	0	0	0	0	0	0	488	0	1,586	0	
RFODOWSR107/22/6682010	25,300	1,207	724.89	103.20	10	10	1	0	0	0	0	0	0	0	0	0	88	88	22	0	1,207	
RFODOWSR107/08/6683000	23,700	1,278	739.73	103.03	11	11	1	0	0	0	0	0	0	0	0	0	0	0	1,278	0	0	
RFODOWSR107/29/6682010	27,350	2,074	753.40	89.59	13	13	1	0	0	0	0	0	0	0	0	0	0	1,037	0	1,037	0	
RFODOWSR107/29/6683020	37,851	1,624	583.32	67.95	14	14	1	0	0	0	0	0	0	0	0	0	88	88	294	0	0	
RFODOWSR107/08/6680010	26,050	1,411	774.47	102.79	11	11	1	0	0	0	0	0	0	0	0	0	0	0	1,411	0	0	
RFODOWSR108/05/6681010	32,300	1,395	784.99	103.43</td																		

Table B-1. (continued).

Document ID Number (Sorted by ID)	Weight (lb)	Volume (ft ³)	Disposal Location ^a (upper left corner)	Disposal Footprint	Waste Volumes by Type (ft ³)												Rocky Flats Plant Wastes					
											Non-Rocky Flats Plant Waste ^c											
			X-axis (ft)	Y-axis (ft)	Width (ft)	Height (ft)	Scale Factor	Series 741 Sludge	Series 742 Sludge	Series 743 Sludge	Series 744 Sludge	Line Generated Waste	Beryllium Contaminated Waste	Roaster Oxide (DUE ^b)	Graphite	Filters	Combustible Debris	Non- Combustible Debris	Sludge	Combustible Debris	Non- Combustible Debris	
RFODOWSR108/19/6680020	36,296	529	592.78	6.99	16	16	1	0	529	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR108/19/6681010	36,208	529	605.58	30.05	10	10	1	250	272	0	0	0	0	0	7	0	0	0	0	0	0	0
RFODOWSR108/19/6682010	26,700	1,157	805.08	91.70	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR108/19/6683010	15,800	1,623	814.17	90.86	12	12	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR108/25/6680000	30,800	2,084	793.38	89.90	13	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR108/25/6681000	26,400	1,934	743.79	69.74	13	13	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR109/12/6680000	32,795	560	610.67	20.09	10	10	1	265	177	0	0	0	0	0	0	0	0	59	0	0	0	0
RFODOWSR109/12/6681010	40,505	1,530	608.53	68.36	13	13	1	176	176	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR109/23/6682000	25,200	1,982	637.60	67.68	15	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR109/30/6680010	32,998	1,731	620.18	85.13	25	20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR109/30/6681020	31,355	1,102	620.34	65.13	25	20	1	0	265	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR109/30/6682010	18,000	1,274	720.17	85.95	30	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR109/30/6683000	21,200	954	710.09	95.87	30	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR109/30/6684000	20,750	1,977	722.31	76.95	21	8	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR110/17/6681010	29,158	1,095	649.98	19.73	11	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR110/17/66820503	26,601	1,073	649.79	49.78	11	11	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR110/21/6683010	21,250	1,967	650.42	55.38	50	20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR110/28/6680050	33,679	558	650.34	65.38	30	20	1	235	235	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR110/28/6681010	32,697	558	650.58	35.38	30	60	1	169	301	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR110/28/6683000	12,850	858	720.17	85.95	50	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR110/28/6684000	28,206	1,132	650.83	5.38	30	30	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR111/04/6683000	22,200	2,074	730.33	66.03	40	20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR111/04/6688080	37,496	1,131	690.42	55.71	20	20	1	0	294	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR111/04/66881060	31,213	1,123	660.67	25.46	30	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR111/04/6682050	36,221	1,117	660.59	35.46	30	15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR112/02/6683010	34,935	1,103	660.50	45.46	30	20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR112/02/6684000	32,540	559	660.84	5.47	35	20	1	0	294	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR112/02/6683030	32,124	557	660.71	20.46	35	20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR112/02/6681010	28,712	1,131	660.59	35.46	35	20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR112/02/6682050	30,584	1,116	675.71	20.58	15	20	1	0	228	154	15	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR112/02/6681020	32,901	559	675.22	80.58	15	5	1	0	374	51	22	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR112/16/6680020	38,213	1,115	675.55	40.58	15	20	1	0	265	59	0	0	0	0	0	0	0	0	0	0	0	0
RFODOWSR112/16/6681020	38,731	1,131	675.38	60.58	15	20	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TAN607SR002/21/67800 ^k	500	15	735.67	21.11	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TAN607SR005/16/66115	80,000	5,750	592.41	84.43</td																		

Table B-1. (continued).

Document ID Number (Sorted by ID)	Weight (lb)	Volume (ft ³)	Disposal Location ^a (upper left corner)			Disposal Footprint			Waste Volumes by Type (ft ³)												
			X-axis (ft)	Y-axis (ft)	Width (ft)	Height (ft)	Scale Factor	Series 741 Sludge	Series 742 Sludge	Series 743 Sludge	Line Generated Waste	Beryllium Contaminated Waste	Roaster Oxide (DU ^b)	Graphite	Filters	Combustible Debris	Non- Combustible Debris	Sludge	Combustible Debris	Non- Combustible Debris	Non-Rocky Flats Plant Waste ^c
Rocky Flats Plant Wastes																					
TAN607SR007/27/66125	6,000	500	664.97	104.78	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	333
TAN607SR008/01/66240	20,000	600	694.97	104.67	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	200	400
TAN607SR008/06/66116	3,000	220	804.96	107.31	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	73	147
TAN607SR010/18/66120	12,000	162	650.14	85.42	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	162	0
TAN607SR010/20/66120	12,000	162	640.10	90.34	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	162	0
TAN607SR012/03/65800	4,000	240	595.14	84.96	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	80	160
TAN633SR004/08/6621000	2,000	130	604.96	106.37	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	43	87
TAN633SR005/02/66130	18,000	800	604.99	103.31	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	800
TRA603SR001/20/67800 ⁱ	4,100	144	685.30	65.70	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	48	96
TRA603SR001/20/67810	1,000	16	685.25	70.71	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	16
TRA603SR006/24/66160	6,000	450	664.97	104.98	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	450
TRA603SR006/24/66210	6,000	216	659.96	106.15	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	72	144
TRA642SR001/24/67820	600	200	690.25	70.75	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	67	133
TRA642SR004/12/66120	3,000	100	600.01	100.00	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	100
TRA642SR004/12/66370	3,000	108	600.01	100.00	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR004/13/66252	3,000	108	600.67	20.01	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR004/28/66251	2,000	108	594.96	106.51	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR004/28/66320	2,000	108	594.96	106.51	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR005/10/66230	2,000	108	639.96	106.88	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR005/10/66496	2,000	108	639.96	106.88	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR005/11/66140	2,000	108	609.96	106.63	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR005/11/66230	2,000	108	604.95	106.59	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR005/11/66340	2,000	108	604.95	106.59	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR005/13/66130	2,000	108	599.96	106.55	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	0	108
TRA642SR011/15/66110	2,000	128	695.09	90.79	10	10	1	0	0	0	0	0	0	0	0	0	0	0	0	43	85
TRA642SR012/20/66210	4,000	150	655.71	15.46	10	10	1	0	0	0	0	0	0	0	0	0	0	0	50	100	
Totals^m	3,183,790	130,007			6,659	5,865	5,433	727	704	1,554	801	1,506	13,183	20,322	47,216	1,279	5,923	18,835			

Notes:

a. Disposal locations are relative to a coordinate system whose origin is located at the northwest monument of Pit 4 with the X-axis parallel to the north boundary of Pit 4.

b. DU = depleted uranium

c. Non-Rocky Flats Plant waste sources include various Idaho National Engineering and Environmental Laboratory (INEEL) generators.

d. ANL = Argonne National Laboratory

e. ARA = Auxiliary Reactor Area

f. CFA = Central Facilities Area

g. CPP = Chemical Processing Plant

h. NRF = Naval Reactor Facility

i. PER = Power Excursion Reactor

j. RFODOW = Rocky Flats Operation - Dow Chemical Company

k. TAN = Test Area North

l. TRA = Test Reactor Area

m. These totals are higher than those reflected in Tables 2 and 3 of EDF-4478. This table has not been adjusted to ignore the portion of some shipments that lie outside of the retrieval grid based on their retrieval footprint location and size.